

Image Cover Sheet

CLASSIFICATION UNCLASSIFIED	SYSTEM NUMBER 498430	
TITLE Optimal Locations for New Casara Units		
System Number:		
Patron Number:		
Requester:		
Notes:		
DSIS Use only:		
Deliver to:		

DEPARTMENT OF NATIONAL DEFENCE CANADA



OPERATIONAL RESEARCH AND ANALYSIS DIRECTORATE OF AIR OPERATIONAL RESEARCH PROJECT REPORT ORA-PR-9610

OPTIMAL LOCATIONS FOR NEW CASARA UNITS

by

G.L. Christopher
(Directorate of Air Operational Research)

and

A. McDonald
(National Search and Rescue Secretariat)

APRIL 1996

OTTAWA, CANADA



National Défense
Defence nationale

OPERATIONAL RESEARCH AND ANALYSIS

CATEGORIES OF PUBLICATION

ORA Reports are the most authoritative and most carefully considered publications of the ORA scientific community. They normally embody the results of major research activities or are significant works of lasting value or provide a comprehensive view on major defence research initiatives. ORA Reports are approved personally by DGOR, and are subject to peer review.

ORA Project Reports record the analysis and results of studies conducted for specific sponsors. This Category is the main vehicle to report completed research to the sponsors and may also describe a significant milestone in ongoing work. They are approved by DGOR or DORA and are subject to peer review. They are released initially to sponsors and may, with sponsor approval, be released to other agencies having an interest in the material.

Directorate Research Notes are issued by directorates. They are intended to outline, develop or document proposals, ideas, analysis or models which do not warrant more formal publication. They may record development work done in support of sponsored projects which could be applied elsewhere in the future. As such they help serve as the corporate scientific memory of the directorates.

ORA Journal Reprints provide readily available copies of articles published with ORA approval, by ORA researchers in learned journals, open technical publications, proceedings, etc.

ORA Contractor Reports document research done under contract for ORA agencies by industrial concerns, universities, consultants, other government departments or agencies, etc. The scientific content is the responsibility of the originator but has been reviewed by the scientific authority for the contract and approved for release by DGOR or DORA.

DEPARTMENT OF NATIONAL DEFENCE

CANADA

OPERATIONAL RESEARCH AND ANALYSIS

DIRECTORATE OF AIR OPERATIONAL RESEARCH

ORA PROJECT REPORT PR 9610

OPTIMAL LOCATIONS FOR NEW CASARA UNITS

by

G.L. Christopher
(Directorate of Air Operational Research)

and

A. McDonald
(National Search and Rescue Secretariat)


Recommended By: J.G. Moscrip, DOR (CAM)
for


Approved By: P.R. Anderson, DGOR

ORA Project Reports present the considered results of project analyses to sponsors and interested agencies. They do not necessarily represent the official views of the Canadian Department of National Defence.

OTTAWA, CANADA

APRIL, 1996

ABSTRACT

In 1976, the Directorate of Air Operational Research (DAOR) undertook a study to identify the optimal regions in Canada where the then newly-forming civil Search and Rescue (SAR) units should be located. In 1995, the Air Command Ottawa Office tasked DAOR to update the study to determine where new CASARA units could be sited to provide the maximum benefit to the SAR system and the Department of National Defence. A methodology, very similar to the one employed in the 1976 study, was utilized to assess the demand for SAR service and the coverage provided by the current CASARA organization. The entire geographic area of Canadian SAR interest was assessed and prioritized with respect to future CASARA unit formation. High demand areas outside of current CASARA coverage were determined to be in northern British Columbia, the Yukon Territory, and the southwestern Northwest Territories. A second region of lesser priority was identified in central Quebec, spanning the area south of Hudson Bay to the mouth of the St. Lawrence River, and extending north into Labrador.

RÉSUMÉ

En 1976, la Direction recherche opérationnelle (Air), DRO(A), entreprenait une étude pour identifier les régions optimales au Canada où les unités civiles de recherche et sauvetage (RES) nouvellement-formées devraient être situées. En 1995, le Bureau du commandement aérien à Ottawa demanda au DRO(A) de faire une mise à jour de l'étude et de déterminer où de nouvelles unités CASARA pourraient être placées pour fournir le bénéfice maximum au système RES et au ministère de la défense nationale (MDN). On utilise une méthodologie très similaire à l'étude de 1976 pour évaluer la demande de service RES et les régions couvertes par l'organisation CASARA d'aujourd'hui. La superficie géographique d'intérêt canadien en RES et les régions prioritaires pour la formation d'unités CASARA ont été évaluées. Les régions non-couvertes par CASARA de plus grande demande en RES se situent dans le nord de la Colombie Britannique, dans le Yukon, et dans le sud-ouest des territoires du Nord-Ouest. En deuxième priorité, on a identifié des besoins dans la région centrale du Québec, couvrant une zone du sud de la Baie d'Hudson à l'embouchure du Fleuve St-Laurent, et se prolongeant vers le nord jusqu'au Labrador.

EXECUTIVE SUMMARY

The Directorate of Air Operational Research (DAOR) was tasked by the Air Command Ottawa Office to update a study that was conducted in 1976. This study identified and prioritized regions in Canada where the establishment of civil Search and Rescue (SAR) units would provide the most benefit to the DND SAR system. At the time of the 1976 study, the organization which came to be called CASARA, Civil Air Search and Rescue Association, was just being formed.

It was decided that an improved, but similar, methodology would be employed in this revised study. The objective of this study was the development of a prioritized list of Canadian regions for the future establishment of CASARA units. Regions were to be prioritized with respect to the maximum benefit a new CASARA unit would provide to the SAR System and the Department of National Defence (DND).

Historical data on SAR air incidents for the time period 1983 to 1991 were collected for the study. All air incidents classified as distress or involving the tasking of DND fixed-wing SAR aircraft were collated into three time periods for the study: 1983-1985, 1986-1988, and 1989-1991. The demand for CASARA service was quantified by estimating the minimum nominal flying time for a DND fixed-wing SAR resource to arrive at the incident site. A geographic reference grid was utilized to assess the total travel time demand for each region in each time period.

Travel time intervals were defined and related to priority categories for CASARA demand assessment. Each grid region was assigned a priority rating for each time period. Results for each time period were compared to assess the temporal stability of the high priority zones.

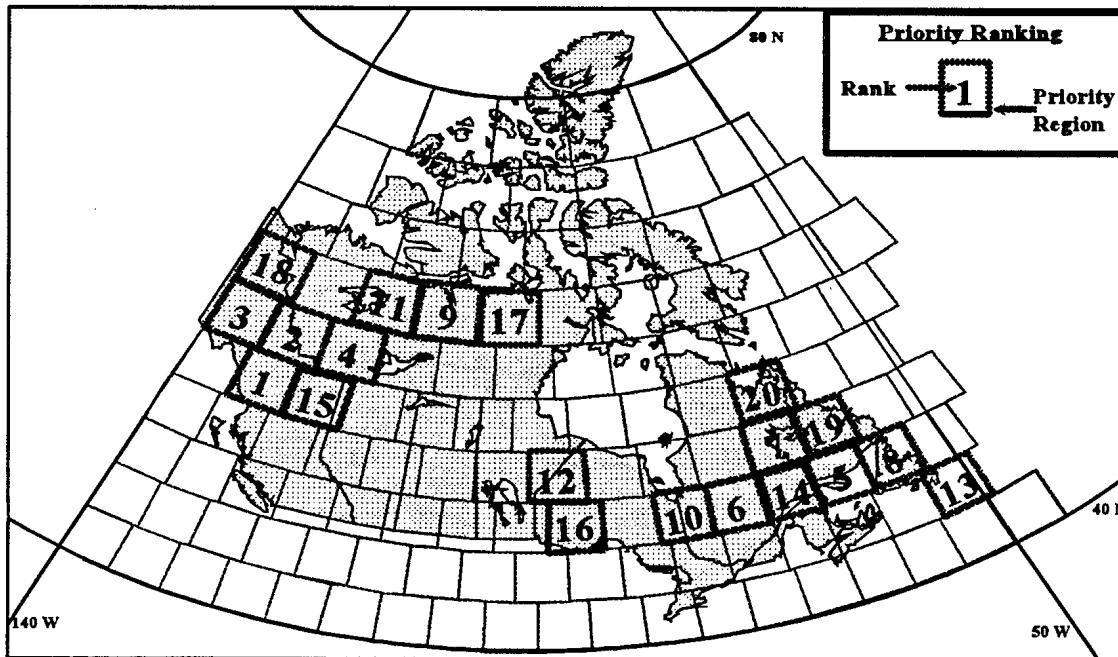
A ranking model utilizing total travel time and temporal stability was applied to produce a priority rank order of the regions. Each grid cell was given a score based on the total travel time, associated with incidents in the cell, weighted by the number of time periods over which the travel time was spread. The region of greatest priority for CASARA development was found to be northern British Columbia and the Yukon Territory. A second priority region was

identified in central Quebec. The locations of the first 20 priority regions are shown in Figure Exec-1.

The regions were prioritized solely from the basis of the demand for CASARA service. It is recommended that the study be expanded to include factors relating to the feasibility of establishing a CASARA unit. The final priority ranking should be based on demand for service and potential for unit formation.

The study noted a large variation in the density of CASARA coverage in different regions of Canada. It is recommended that a study be undertaken to evaluate the optimum level of overlap between CASARA units and the most effective distribution of existing units.

Data describing SAR incidents occurring after 1991 were not available at the time of this study. It is recommended that the study be redone with data from 1992 to 1995, when the data become accessible. This would expand the basis for the evaluation and increase the statistical significance and confidence in the results.



**FIGURE EXEC-1:REGIONAL PRIORITY RANK ORDER (1-20)
FOR FUTURE CASARA UNIT DEVELOPMENT**

TABLE OF CONTENTS

	<u>Page</u>
ABSTRACT/RÉSUMÉ	i
EXECUTIVE SUMMARY	ii
TABLE OF CONTENTS	iv
LIST OF FIGURES	vi
LIST OF TABLES	viii
INTRODUCTION	1
BACKGROUND	1
PERSPECTIVE	1
STUDY OBJECTIVES	2
STUDY PARTICIPATION	3
METHODOLOGY	4
GENERAL	4
GEOGRAPHIC REFERENCE GRID	4
MEASURE OF SAR DEMAND	6
TRANSIT TIME	7
SAR BASES AND AIRCRAFT	7
HISTORICAL CASARA SAR REQUIREMENT	9
SAR Cases Utilized	9
Time Period Coverage	10
DEMAND PRIORITY CATEGORIES	11
TEMPORAL STABILITY ASSESSMENT	12
GRID CELL RANK ORDERING	13
CURRENT CASARA COVERAGE	15
GENERAL ASSESSMENT PROCEDURE	17
RESULTS	19
TRUE DISTRESS INCIDENT SAR DEMAND	19
PERCEIVED DISTRESS INCIDENTS	25
COMPARISON OF INCIDENT CLASSES	30
PRIORITY CONSISTENCY	31
CURRENT CASARA COVERAGE	36
SAR DEMAND BEYOND CASARA COVERAGE	38
BEYOND-COVERAGE SAR DEMAND CONSISTENCY	43
REGIONAL PRIORITIZATION FOR CASARA DEVELOPMENT	43

TABLE OF CONTENTS (Cont'd)

	<u>Page</u>
CONCLUSIONS	52
PRESENT CASARA COVERAGE	52
HIGH PRIORITY REGIONS	53
ADDITIONAL FACTORS	54
RECOMMENDATIONS	54
Expanding Assessment Basis	54
Coverage Density Assessment	55
Future Evaluations	55
REFERENCES	57
ANNEX A	A-1

LIST OF FIGURES

	<u>Page</u>
FIGURE 1: GEOGRAPHIC REFERENCE GRID	5
FIGURE 2: DND SAR BASES AND FIXED-WING AIRCARFT	8
FIGURE 3: CASARA UNIT LOCATIONS	16
FIGURE 4: AIR DISTRESS INCIDENT LOCATIONS (1983-1991) . . .	21
FIGURE 5: GRID CELL PRIORITY RATINGS - PERIOD 1 (1983-1985) BASED ON DISTRESS AIR INCIDENTS	22
FIGURE 6: GRID CELL PRIORITY RATINGS - PERIOD 2 (1986-1988) BASED ON DISTRESS AIR INCIDENTS	23
FIGURE 7: GRID CELL PRIORITY RATINGS - PERIOD 3 (1989-1991) BASED ON DISTRESS AIR INCIDENTS	24
FIGURE 8: PERCEIVED DISTRESS AIR INCIDENT LOCATIONS . . .	26
FIGURE 9: GRID CELL PRIORITY RATINGS - PERIOD 1 (1983-1985) BASED ON PERCEIVED DISTRESS AIR INCIDENTS . . .	27
FIGURE 10: GRID CELL PRIORITY RATINGS - PERIOD 2 (1986-1988) BASED ON PERCEIVED DISTRESS AIR INCIDENTS . . .	28
FIGURE 11: GRID CELL PRIORITY RATINGS - PERIOD 3 (1989-1991) BASED ON PERCEIVED DISTRESS AIR INCIDENTS . . .	29
FIGURE 12: CELLS OF CONSISTENT VERY HIGH PRIORITY BASED ON PERCEIVED DISTRESS AIR CASES 1983-1991	32
FIGURE 13: CELLS OF CONSISTENT HIGH OR VERY HIGH PRIORITY BASED ON PERCEIVED DISTRESS AIR CASES 1983-1991	33
FIGURE 14: CELLS OF MODERATELY CONSISTENT VERY HIGH PRIORITY BASED ON PERCEIVED DISTRESS AIR CASES 1983-1991	34
FIGURE 15: CELLS OF MODERATELY CONSISTENT HIGH OR VERY HIGH PRIORITY BASED ON PERCEIVED DISTRESS AIR CASES 1983-1991	35
FIGURE 16: CASARA GEOGRAPHIC COVERAGE	37
FIGURE 17: PERCEIVED DISTRESS AIR INCIDENTS BEYOND CASARA COVERAGE (1983-1991)	39

LIST OF FIGURES (Cont'd)

	<u>Page</u>
FIGURE 18: GRID CELL PRIORITY RATINGS - PERIOD 1 (1983-1985) BASED ON PERCEIVED DISTRESS AIR INCIDENTS BEYOND CASARA COVERAGE	40
FIGURE 19: GRID CELL PRIORITY RATINGS - PERIOD 2 (1986-1988) BASED ON PERCEIVED DISTRESS AIR INCIDENTS BEYOND CASARA COVERAGE	41
FIGURE 20: GRID CELL PRIORITY RATINGS - PERIOD 3 (1989-1991) BASED ON PERCEIVED DISTRESS AIR INCIDENTS BEYOND CASARA COVERAGE	42
FIGURE 21: CELLS OF CONSISTENT VERY HIGH PRIORITY BASED ON PERCEIVED DISTRESS AIR CASES BEYOND CASARA COVERAGE 1983-1991	44
FIGURE 22: CELLS OF CONSISTENT HIGH OR VERY HIGH PRIORITY BASED ON PERCEIVED DISTRESS AIR CASES BEYOND CASARA COVERAGE 1983-1991	45
FIGURE 23: CELLS OF MODERATELY CONSISTENT VERY HIGH PRIORITY BASED ON PERCEIVED DISTRESS AIR CASES BEYOND CASARA COVERAGE 1983-1991	46
FIGURE 24: CELLS OF MODERATELY CONSISTENT HIGH OR VERY HIGH PRIORITY BASED ON PERCEIVED DISTRESS AIR CASES BEYOND CASARA COVERAGE 1983-1991	47
FIGURE 25: REGIONAL PRIORITY RANK ORDER (1 TO 20) FOR CASARA UNIT DEVELOPMENT BASED ON PERCEIVED DISTRESS AIR CASES 1983-1991	51

LIST OF TABLES

	<u>Page</u>
TABLE I: SAR AIRCRAFT AND BASES	7
TABLE II: TRUE DISTRESS AIR CASES BY TIME PERIOD	19
TABLE III: PERCEIVED DISTRESS AIR CASES BY TIME PERIOD . .	25
TABLE IV: GRID CELL PRIORITY RANKING BASED ON PERCEIVED DISTRESS AIR CASES BEYOND CURRENT CASARA COVERAGE 1983-1991	50

OPTIMAL LOCATIONS FOR NEW CASARA UNITS

I. INTRODUCTION

BACKGROUND

1. In 1976, the Directorate of Air Operational Research (DAOR) undertook a study (Ref. 1) to determine the most effective locations to establish civil Search and Rescue (SAR) squadrons. At that time, the organization of civil aviation support to SAR was just beginning. It was of utmost importance, both for SAR support to the Department of National Defence (DND) and the longevity of the developing organization, that the civil SAR units be located in areas where their activities would provide maximum benefit. The organization subsequently came to be known as the Civil Air Search and Rescue Association, CASARA.
2. Following a presentation on operational research support to SAR (Ref. 2), which included a description of the 1976 study, the Air Command Ottawa Office (ACOO) requested that DAOR update the study (Ref. 3) with the most recent data available. The request noted that a review of CASARA and SERABEC, Quebec equivalent of CASARA, basing locations was being undertaken "with the goal of ensuring that units are located in areas which are of maximum benefit to the SAR system".

PERSPECTIVE

3. From discussions with the sponsor, it was decided that the study would be approached from the perspective of "continuous improvement" consistent with the philosophy of total quality management in DND. As there are no minimum standards that must be achieved in selecting the number and location of CASARA units, the logical approach to the problem was to assess the current situation and attempt to identify changes that would improve the overall performance of the system. The potential changes would be prioritized to

- 2 -

ensure that attention would be focussed on those areas where maximum benefit would be obtained.

STUDY OBJECTIVES

4. Given the perspective of the study, two objectives were identified:

- a. assess current demand for CASARA support and assess CASARA positioning relative to the demand, and
- b. identify areas where the establishment of new CASARA units would be of maximum benefit to the SAR system.

5. The first objective seeks to determine if the current demand for SAR services is uniform across the Canadian SAR area of interest or if there are certain geographic regions which generate a greater than average demand for SAR activity. Past studies (Ref. 4, 5, and 6) have shown that there are specific regions in Canada which are "hot spots" for SAR activity relative to the rest of the Canadian SAR region.

6. If high demand regions exist, they can be compared to the SAR coverage provided by the current distribution of CASARA units. An assessment can be made as to the adequacy of the current CASARA coverage of the high demand areas.

7. The second objective for the study strives to identify which regions, currently outside of CASARA coverage, have the greatest demand for CASARA-supportable SAR service. This phase of the evaluation will assist in prioritizing regions for the establishment of new CASARA units. The results of this assessment will permit SAR management to focus on specific regions of the country where the development of new CASARA units would provide the greatest positive impact to the SAR system.

- 3 -

STUDY PARTICIPATION

8. During the briefing on operational research support to SAR (Ref. 2), the National SAR Secretariat (NSS) Executive officers noted the mutual interest in SAR operational studies of the NSS and DND. An offer of NSS cooperation and support on future DND SAR studies was made. DND representatives acknowledged the benefits of such research cooperation in SAR. It was resolved that DND would attempt to coordinate SAR analysis activities with the NSS when suitable SAR studies were initiated.

9. The proposed CASARA basing study was discussed with the NSS. It was decided that the study was of interest to the NSS, as well as DND. The NSS agreed to provide analytical support to the study. The evaluation of CASARA unit locations became a joint project between the NSS and DAOR.

II. METHODOLOGYGENERAL

10. It was decided that the methods to be used in this evaluation should follow, as closely as possible, those used in the 1976 study. This approach would facilitate a comparison of the results of the two studies. However, such a comparison was not conducted as part of this project. Any interested reader should find it easy to compare the high demand regions identified in the studies from the associated reports.

GEOGRAPHIC REFERENCE GRID

11. As in the 1976 study, the first step in the evaluation was to divide the approximate geographic area of Canadian SAR interest into a reference grid of map cells. However, unlike the 1976 study where the angular dimensions of the cells were kept constant, in this study the cartographic area of each cell was held invariant. Keeping the physical area of the grid cells constant provided a consistent basis for comparisons between cells when assessing SAR demand. This approach also possesses the feature that the number of SAR cases occurring in any grid cell is directly proportional to the case density for the cell, allowing regional incident density to be compared by the total number of SAR cases occurring in the grid cells.

12. A map displaying the reference grid is shown in Figure 1. The origin of the grid is located at 140 degrees West Longitude, 40 degrees North Latitude. Each cell in the bottom row is four degrees of latitude high by five degrees of longitude wide, consistent with the 1976 study. The angular height of every row was kept constant at four degrees of latitude. The width of each grid cell varies from row to row to maintain a constant cell area of about 55,200

- 5 -

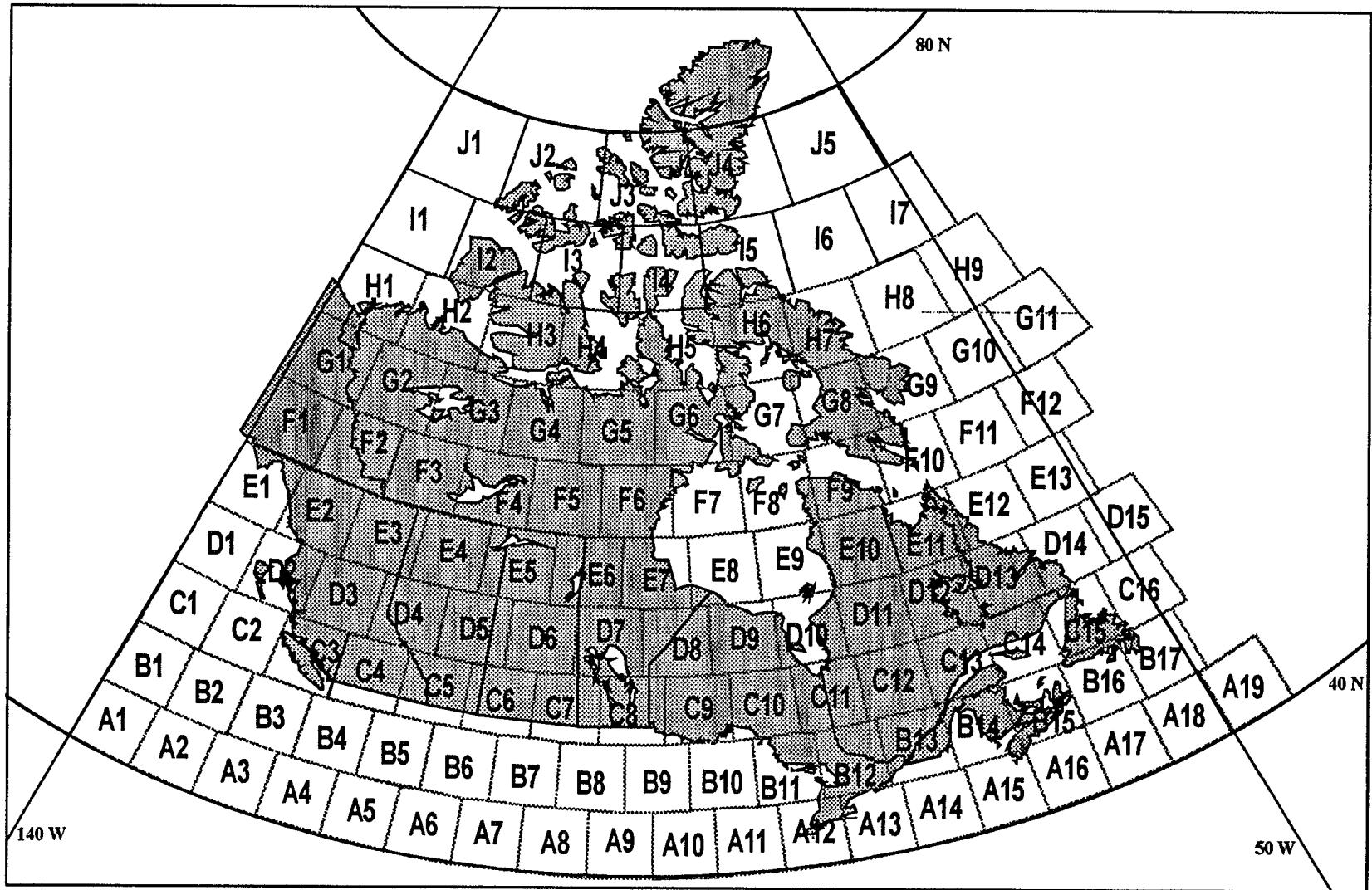


FIGURE 1 : GEOGRAPHIC REFERENCE GRID

- 6 -

square nautical miles, which is of the order of the size of the coverage area of a CASARA unit operating from a single airfield. Each cell was uniquely labeled for identification. The entire area of SAR interest comprised 124 grid cells.

MEASURE OF SAR DEMAND

13. The principal support provided by CASARA is in locating the SAR incident site during the search phase of the SAR operation. As the CASARA search platforms are usually small fixed-wing aircraft, the ability of CASARA to deploy to the incident site to render aid is very limited. The main benefit to DND of CASARA is to reduce the search time associated with the incident. As well as reducing the time from incident occurrence to the provision of assistance to the incident victim(s), CASARA support reduces the flying hours of DND aircraft to perform the search. In fortuitous circumstances, CASARA can locate the incident site before DND has tasked any air resources to participate in the search.

14. To deploy to the incident site, provide aid, and transport the victims to medical facilities, usually requires DND to fly a helicopter to the accident site. The support of CASARA during the rescue phase of the operation usually has a minimal impact on the utilization of DND resources. In terms of maximum benefit to DND, CASARA could potentially eliminate the transit and search time of DND fixed-wing SAR aircraft during the search operation of the SAR incident.

15. Potential search time for a SAR incident is a difficult factor to estimate. However, aircraft transit time to a site is relatively simple to calculate. It was decided that transit time would be used as the measure of SAR demand on DND that could be influenced by CASARA. The use of transit time as the key factor to evaluate CASARA unit location effectiveness is consistent with the 1976 study.

TRANSIT TIME

16. For this study, transit time was assessed as the minimum flying time for DND fixed-wing SAR aircraft to arrive at the SAR incident site. The flying time was estimated for each DND fixed-wing SAR aircraft type deploying from their associated base. Nominal flying time was calculated by taking the shortest great-circle distance from the aircraft base to the incident site and dividing by the aircraft transit speed. The shortest flying time of all the possible aircraft was taken as the transit time for the incident.

SAR BASES AND AIRCRAFT

17. The study sponsor specified that only the aircraft and base combinations shown in Table I would be used for the purposes of calculating incident transit time. Also shown in Table I are the transit speeds of the aircraft used in this study. The locations of the bases are shown on the map displayed in Figure 2.

TABLE I : SAR BASES AND AIRCRAFT

<u>Base</u>	<u>Aircraft</u>	<u>Transit Speed</u>
Comox	Buffalo (CC115)	210 Kts
Winnipeg	Hercules (CC130)	300 Kts
Trenton	Hercules (CC130)	300 Kts
Greenwood	Hercules (CC130)	300 Kts

- 8 -



FIGURE 2 : DND SAR BASES AND FIXED-WING RESOURCES

- 9 -

18. From Figure 2, it can be seen that the SAR bases are well distributed across the breadth of the country. Hercules SAR aircraft are stationed on the three eastern bases, while the Buffalo aircraft are based on Vancouver Island on the West coast.

19. With only two types of SAR fixed-wing aircraft and the slowest aircraft type based on the West coast, the shortest transit time to incidents occurring in Central and Eastern Canada was determined by the flying time from the nearest base to the site. In Western Canada, the quickest responding base was not always the nearest one due to the two different SAR aircraft types operating in the area. In some cases the fastest response came from Winnipeg with the faster Hercules aircraft, even though Comox was the closer base.

HISTORICAL CASARA SAR REQUIREMENT

20. SAR Cases Utilized. The requirement for SAR services, both DND and CASARA, was defined from a historical collection of SAR cases as recorded in the SARSTAT and SARIS databases¹. As DND's mandate is to respond to air distress incidents and the vast majority of CASARA support is with respect to this class of SAR incident, only air distress cases were used to quantify the demand for DND and CASARA SAR.

21. The recording of data in the two SAR databases is less than perfect. For any particular SAR case, any number of data parameters may be left unrecorded in the database. In some cases the air incident is not specifically recorded as a distress case although the noted loss of lives would dictate that the incident was a distress case. For this

1. SARSTAT MK II was the official DND electronic data repository for SAR case information from 1983 to 1987. To address noted deficiencies in the SARSTAT database, a completely redeveloped database, SARIS, became the official DND SAR database from 1988 to 1991.

- 10 -

reason several criteria were used to qualify a SAR air case as a distress incident. The specific search rules used to classify and retrieve air distress cases are identified in Annex A.

22. While examining the databases, it was noted that there were a large number of SAR air cases which could not be unambiguously classified as distress incidents, but for which DND tasked SAR aircraft to respond. For this study, it was assumed that if SAR aircraft were tasked to respond to an incident then the Rescue Coordination Centre (RCC) must have believed, at some time during the case, that the incident involved potential distress. It was decided that these cases should also be included in the evaluation.

23. The inclusion of the perceived (potential) distress air cases was also justified from the consideration that DND would task CASARA units to investigate any air incident for which a DND SAR aircraft would be tasked. It is reasonable to expect that for these perceived incidents CASARA units would have been used if they were available. This collection of incidents can reasonably be considered as a component of the total requirement for CASARA services.

24. Hence, the evaluation of CASARA base locations utilized two categories of air incidents: true distress cases and perceived distress cases. The collection of perceived distress cases was formed as a superset of the "true" distress air incidents and the other air incidents for which DND SAR aircraft were tasked to respond.

25. Time Period Coverage. It was desirable to collect the SAR cases from as broad and most recent time period as possible to provide the evaluation with statistical significance and accurate assessment of current requirements. Ease of data access was an additional consideration that had a major effect on the final decision of the time period to be used.

26. Both DAOR and NSS have local copies of the SARSTAT and SARIS SAR databases covering the years 1983 to 1991,

- 11 -

inclusive. Data from 1992 and later years are stored (or are in the process of being entered) in the Canadian Coast Guard database SISAR. Arrangements are underway to provide DND with direct access to this database, but at the time of this study complete access was not yet available.

27. For the aforementioned reasons, the evaluation of CASARA basing was restricted to utilizing SAR case data covering the time span 1983 through 1991.

28. It was important for the evaluation to obtain an assessment of the stability of SAR demand over time, i.e., to examine if the high demand areas change location over the years. To address this issue, the data set was subdivided into three time periods: 1983-85, 1986-88, and 1989-91. Results for each of the time periods were produced and compared to obtain a general assessment of the temporal stability for CASARA SAR demand.

DEMAND PRIORITY CATEGORIES

29. Travel time intervals were chosen as priority category boundaries to allow each grid cell to be classified within a hierarchy of demand levels. There are no existing predefined standards by which to rate the severity of SAR demand in terms of travel time. A relative scale based on the cumulative frequency distribution of travel times was established to classify each grid cell as one of five priority categories.

30. The values of the sum of travel time for each time period and grid cell were sorted into a single cumulative frequency distribution of increasing travel time. The five priority categories were defined by the travel time values of selected percentile ranges within the distribution. A "Very High" priority category was specified as the 95th to 100th percentile range in the distribution. A "High" priority was set as the 85th to, but not including, the 95th percentile range. A "Moderate" priority was set by the

interval from the 70th to 85th percentile (not inclusive). A "Low" priority category covered the range of the 50th percentile to, but not including, the 70th percentile. The final category was the "Nil" priority which comprised the set of travel time values below the 50th percentile of the cumulative frequency distribution.

31. Each grid cell was given three priority ratings corresponding to each of the three time periods. Each priority category was colour coded and map charts showing the priority rating of each grid cell were prepared for each time period.

32. Admittedly, the selection of the percentile values used to rank the priority of the grid cells was somewhat arbitrary. However, the model is consistent with the approach of continuous improvement chosen for the study. Clearly the priority of a region for CASARA unit location should be a function of the demand for SAR service, with the highest priority given to the regions with the greatest demand. The correlation applied between priority rating and rank within the cumulative frequency distribution supports this approach. The highest priority regions would be ranked in the upper extreme of the cumulative frequency distribution. The selection of the specific rank values to separate the priority categories was arbitrary. The value selection was based upon the desire to restrict the number of qualifying regions in the higher priority categories to relatively small numbers to facilitate assessment and prioritization of the region for future CASARA unit development.

TEMPORAL STABILITY ASSESSMENT

33. An assessment of the consistency of the locations of the high priority regions was performed through a comparison of the results for each time period. Two categories of temporal stability were specified for this assessment: "Consistent" and "Moderately Consistent".

- 13 -

34. A consistent level of priority was defined as the condition whereby a grid cell retained the same priority rating or a higher rating in all three time periods. For example, grid cells of consistent high priority would be those cells that had a priority rating of high or very high in each of the three time periods.

35. A moderately consistent level of priority was specified as the situation where a grid cell received the same or higher priority rating in two of the three time periods. As a hypothetical example, consider a grid cell that was rated as moderate priority in the first time period, high priority in the second time period, and very high priority in the last time period. The cell would receive a temporal stability rating of moderately consistent high priority because it had a rating of high priority or greater in two of the three time periods.

GRID CELL RANK ORDERING

36. The last step in the process to support the optimization of the basing locations for CASARA units was to identify a priority list of grid locations for the establishment of new CASARA units. The locations rated as the highest priority would provide the greatest incremental benefit to CASARA-assisted SAR service.

37. It is noted that some of the grid cell regions are not feasible locations for CASARA establishment, due to their being situated in an ocean area or simply outside of Canadian territory. For simplicity and completeness, these cells were included in the prioritization process.

38. Several potential methods were available to conduct the final rank ordering of the grid cells. Each method has inherent merits and emphasizes different desirable goals in identifying the relative priority of cell

zones for CASARA development. Three methods were ultimately applied to the data in this study to produce priority rank orderings of the grid areas.

39. The first method awarded a score to each grid cell according to its priority rating in each time period. Points were awarded as follows: four points for a very high priority rating, three points for a high priority rating, and so forth, ending with zero points given for a nil priority rating. The scores for each time period were then summed for each grid cell and the cells were ordered according to decreasing total score.

40. This method had the feature that it utilized the same priority category structure used to assess the relative demand priority of the grid cells. This rating scheme was a logical extension of the method used to examine demand priority and temporal stability.

41. The second ranking method examined was very similar in procedure to the first method. The cumulative distribution of travel time was divided into five equally populated intervals: zero to 20th percentile, 20th to 40th percentile, 40th to 60th percentile, 60th to 80th percentile, and 80th to 100th percentile. A weight corresponding to the expected values of a normal distribution centred on the 50th percentile was associated with each of the intervals. Each grid cell received a score corresponding to the weight associated with the distribution interval applicable to the cell for each time period. The scores for the three time periods were summed for each grid cell and the cells were sorted according to total score.

42. This second ranking model possesses the advantage that it uses a relatively standard approach to dividing the travel time distribution into uniform intervals, as opposed to the somewhat arbitrary separations used by the first method. This method is basically a "bell curve" approach to ranking the grid cells. The method does have the disadvantage that it assumes that a normal distribution is a fair representation of the travel time data.

- 15 -

43. The last method applied involved using the total travel time, for all three time periods, associated with the grid cell as the score. The score was then modified by a factor based on the proportion of time periods over which the travel time was distributed, i.e. the percentage of time periods with travel time greater than zero. (For example, a grid cell with travel times of 24, 0, and 15 hours for each time period respectively, would be given a score of: $39 \times 2/3 = 26$.) The grid cells were ranked according to their final modified score values.

44. This method provided a unique rank value for each grid cell based on the magnitude of the total SAR demand. The method allowed an assessment of the relative difference between cell ranking to be made. Grid cells which are in consecutive positions in the rank order can actually be widely separated in terms of consistent SAR demand. This ranking method allows this attribute to be examined.

45. It was felt that one of the most desirable attributes of a location being considered for a CASARA unit should be a consistently high demand for CASARA service. Continual use of the CASARA unit would be beneficial in maintaining motivation and readiness, while high demand ensures that maximum benefit is obtained from the unit. For these reasons and the sake of brevity, only the results of the third ranking method will be presented in detail in this report, although a brief comparison of the results of the three methods will be described.

CURRENT CASARA COVERAGE

46. A network of CASARA volunteer units has been established across the country and has been in operation since the late seventies. A listing of the locations of CASARA units currently operational was provided by the CASARA National Administrator at AIRCOM Headquarters. Figure 3 shows the geographic locations of the current establishment of CASARA units.

- 16 -

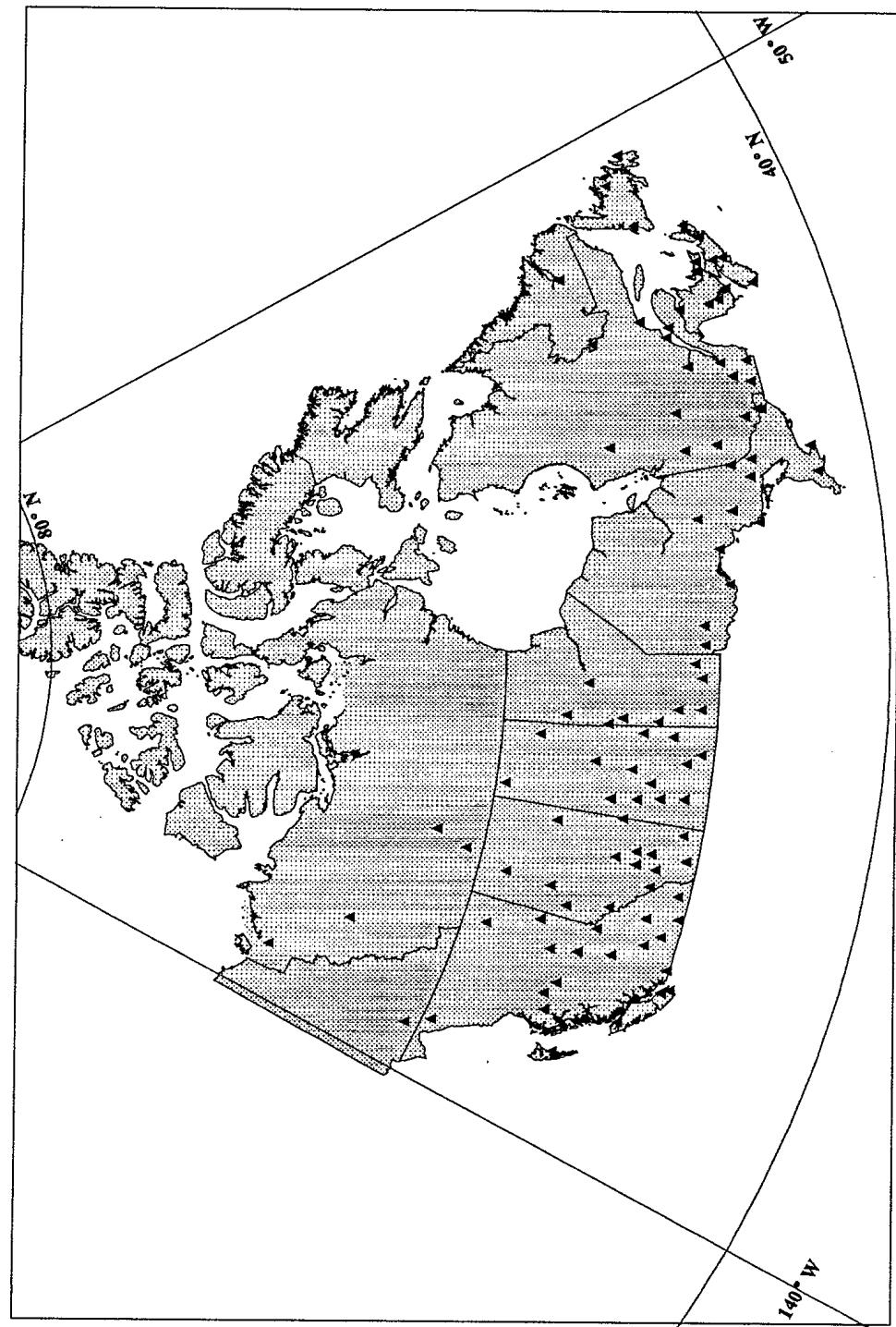


FIGURE 3 : CASARA UNIT LOCATIONS

- 17 -

47. For the purposes of assessing coverage, it was assumed that the radius of operation of a CASARA unit was one hundred nautical miles² around its operating base. A coverage map was prepared utilizing this assumption and was used to assess the existing coverage pattern against the areas of greatest SAR demand.

GENERAL ASSESSMENT PROCEDURE

48. The first step in the assessment process was the calculation of the travel times for the true distress air cases for each time period. The grid cells were then evaluated for priority category based on the cumulative frequency distribution. Each priority category was given a colour code and maps displaying the results were prepared.

49. The same actions were performed for the set of perceived distress air cases. Maps were again prepared to display results.

50. A comparison of the results for the two sets of historical cases was conducted to ascertain if there was consistency or a significant difference between the general locations of the high priority areas. Assuming that the omission of data to qualify a SAR case as a perceived distress incident was an unbiased random process, one would expect the normalized results for the two data sets to be very similar.

51. Next, the grid cells which qualified as consistent very high priority areas, consistent high or very high priority areas, moderately consistent very high priority areas, and moderately consistent high or very high priority

2. CASARA operating range was derived from the consideration that the small aircraft flown by CASARA units have a flight endurance of approximately three hours and transit speed of about 100 knots. Allowing for a one hour transit out, one hour search time, and one hour transit back to base yields a coverage radius of roughly 100 nautical miles.

- 18 -

areas were identified. Maps showing the locations of the grid areas meeting the criteria of the four temporal priority categories were plotted and compared.

52. The current coverage provided by CASARA was assessed against the priority areas for air distress SAR identified in the temporal priority maps.

53. To identify and prioritize the regions for future CASARA development, the SAR incidents located within the coverage zones of CASARA units were removed from the historical data sets. The cumulative frequency distributions were recalculated and the grid cells were reassigned priority categories based on the revised distributions. Zones with consistent and moderately consistent temporal stability and high or very high priority were determined.

54. Finally, the rank ordering methods were applied to prioritize the grid cells for future CASARA unit establishment based on the historical SAR demand currently outside of CASARA coverage.

- 19 -

III. RESULTS

TRUE DISTRESS INCIDENT SAR DEMAND

55. Utilizing the selection rules described in Annex A, SAR cases qualifying as genuine air distress incidents were extracted from the SAR databases. A total of 1059 cases was collected from the databases. Table II lists the number of qualifying incidents for each time period, and a map displaying the locations of the incidents is shown in Figure 4.

TABLE II : TRUE DISTRESS AIR CASES BY TIME PERIOD

Time Period	Period 1 1983-1985	Period 2 1986-1988	Period 3 1989-1991
Number of SAR Cases	329	397	333

56. From the map, it can be seen that incident sites are widely dispersed throughout most the Canadian region. In addition, there are exceptionally high concentrations of incidents around Vancouver Island, the Great Lakes, and the St. Lawrence Seaway.

57. The minimum nominal travel time to each incident by a DND SAR fixed-wing resource was calculated. The minimum travel time for all the incidents occurring in each grid cell was summed for each time period. Each grid cell was given a priority rating for each time period based on the relative rank within the cumulative frequency distribution of total travel time. The priority rating of each grid cell for each time period is displayed in Figures 5 to 7, respectively.

- 20 -

58. In Figures 5 to 7, the index identifies the colour corresponding to the various priority ratings, starting with white for nil priority going to red for very high priority. The numbers on the right-hand side in the index indicate the travel time range, in hours, corresponding to the priority category. The number in brackets lists the number of grid cells on the map which have the associated priority rating. The number in the grid cells on the map indicates the number SAR incidents that were involved in producing the cell priority rating for the time period.

59. From Figures 5 to 7, it can be seen that British Columbia, Alberta, northwestern Saskatchewan, and areas in the Yukon and western Northwest Territories are dominated with very high and high priority areas in each time period. Southern Quebec and Labrador also feature high and/or very high priority areas in each of the time periods. The general areas where the high priority zones are located remains generally stable across the three time periods.

60. The second time period, 1986 to 1988, had 50 percent more grid cells in the higher two priority categories than either of the other two time periods. The second time period also had approximately 21 percent more SAR cases in total than either of the other two time periods. The increase in high priority regions is disproportionate to the number of additional SAR cases. Also, there is a shift in the proportion of SAR incidents occurring in the more distant geographic zones in the second time period. No attempt was made to identify the cause of this observed anomaly.

61. It is interesting to note that the regions farthest away from SAR bases, where one might expect to see high priority ratings due to the extended travel times required to reach the regions, have very low priority ratings. The small number of incidents which occur in these areas compensates for the large travel times involved with the incidents to produce relatively low total travel time requirements.

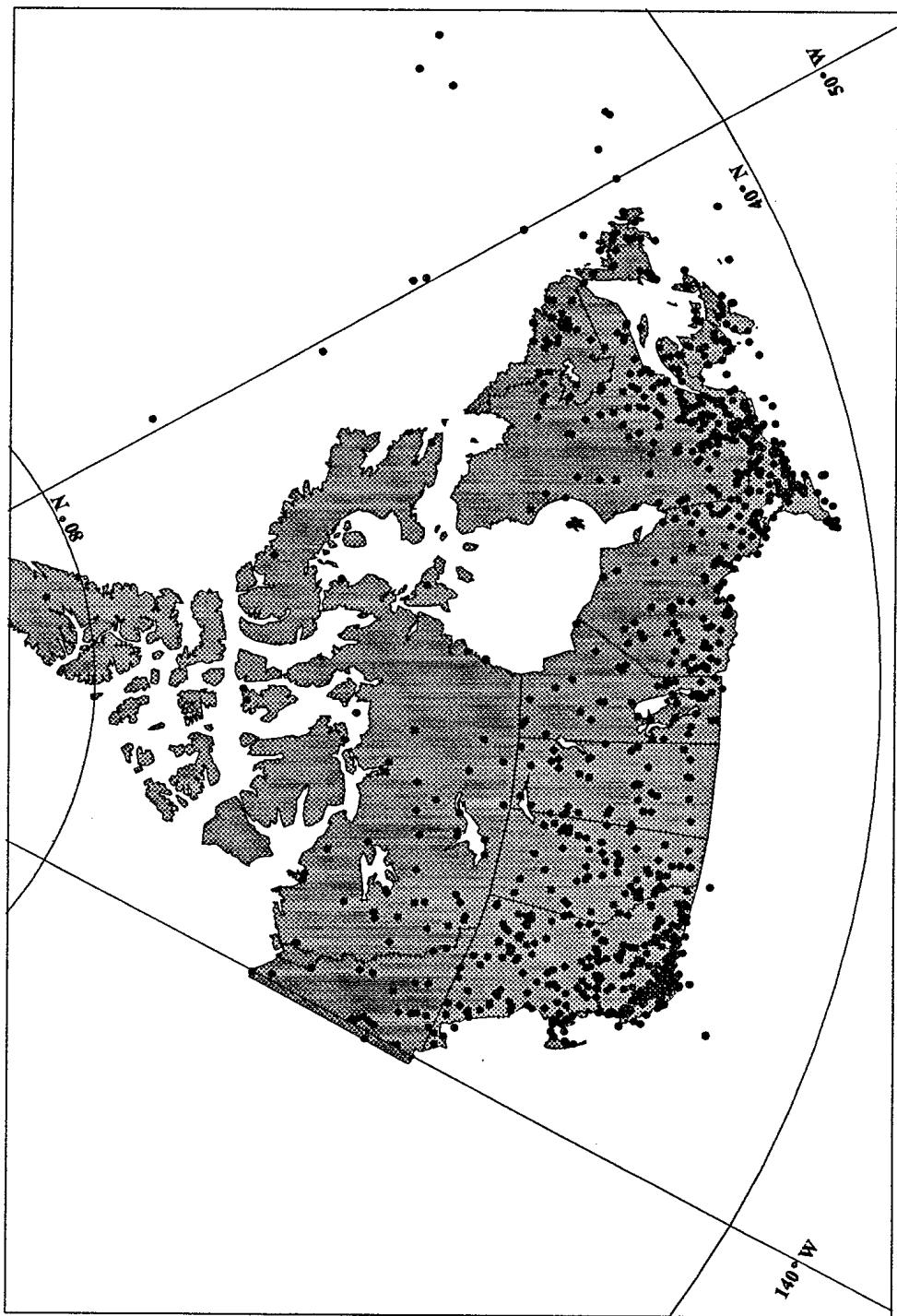


FIGURE 4 : AIR DISTRESS INCIDENT LOCATIONS (1983-1991)

-22-

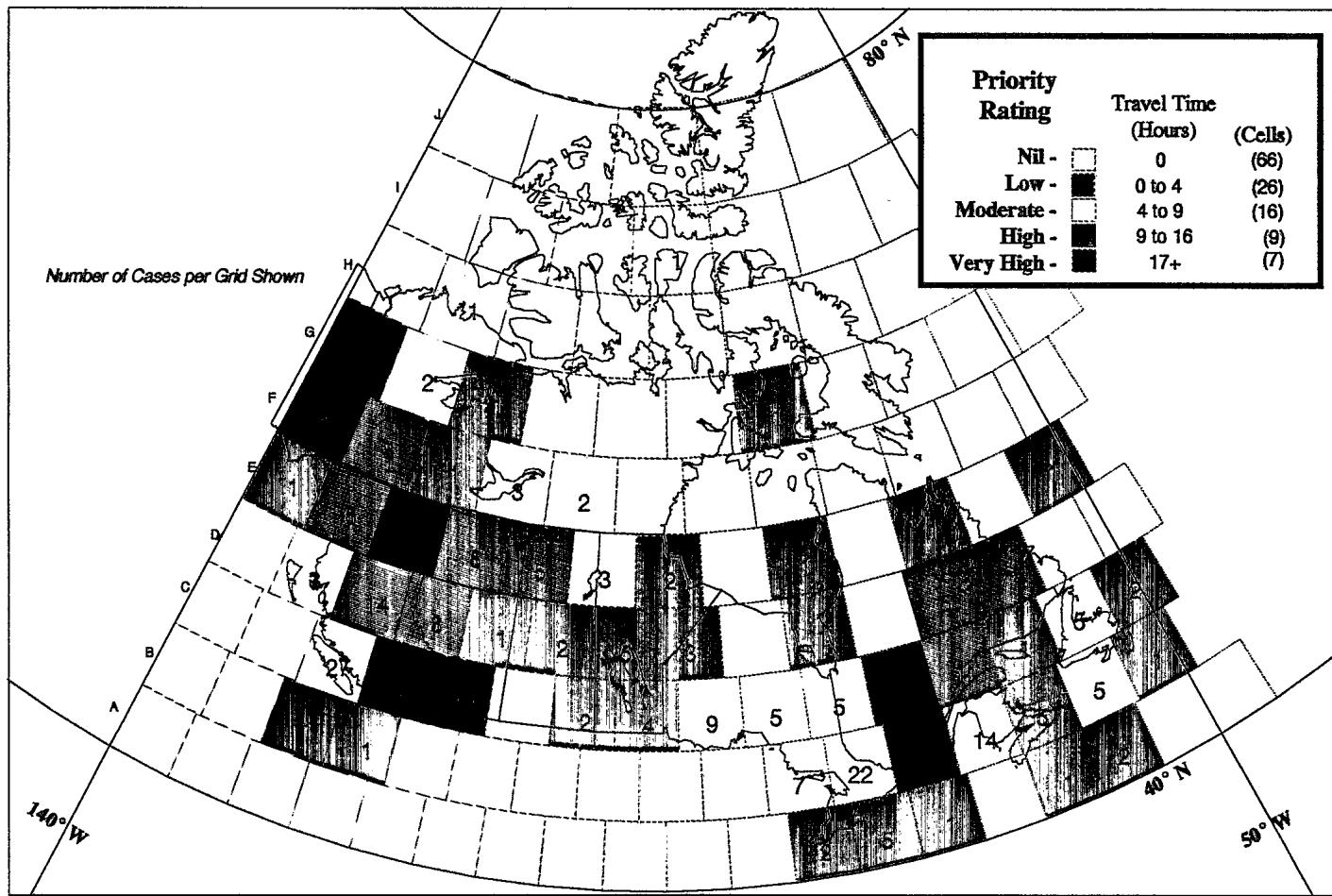


FIGURE 5 : GRID CELL PRIORITY RATINGS - PERIOD 1 (1983-1985)
BASED ON DISTRESS AIR INCIDENTS

-23-

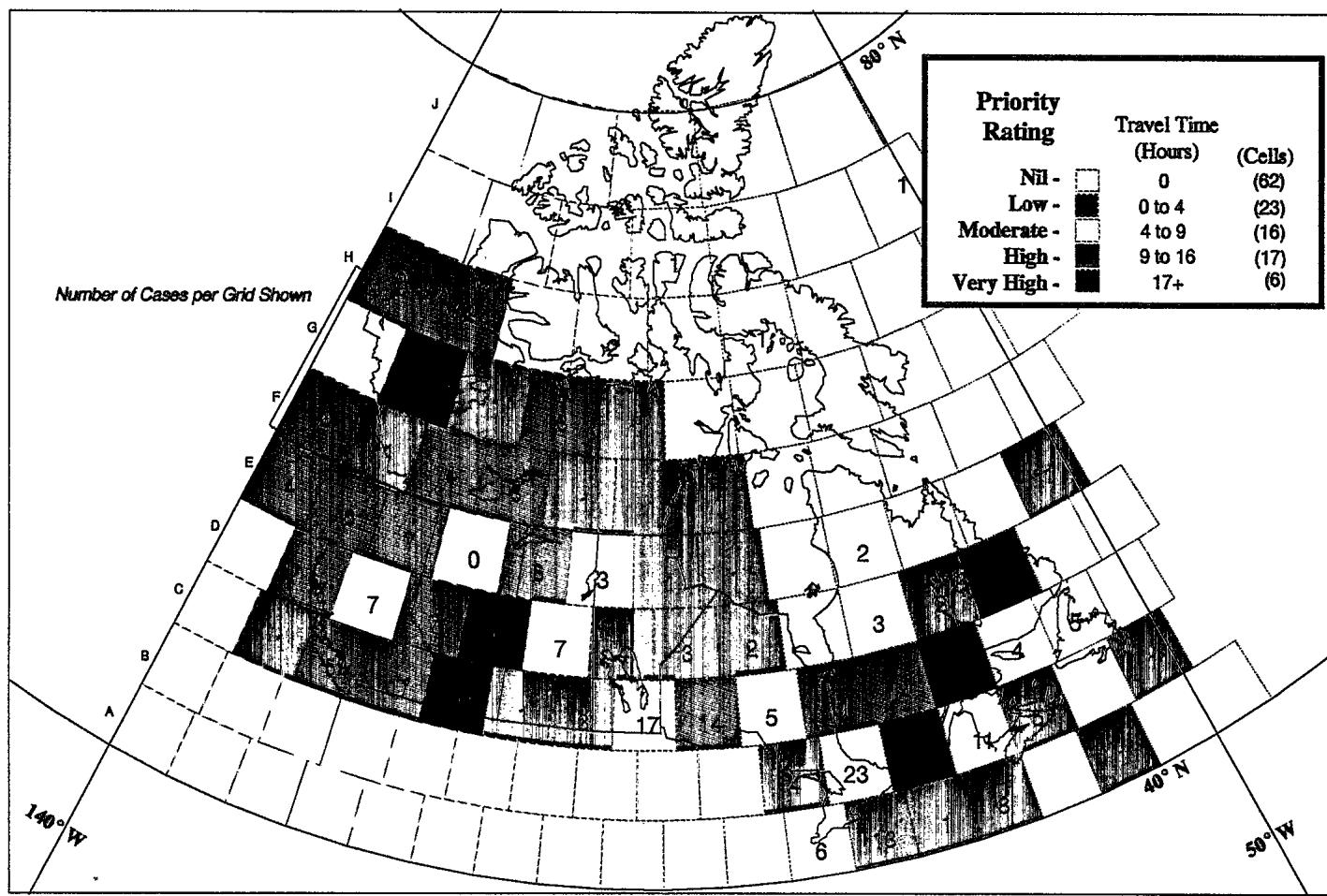


FIGURE 6 : GRID CELL PRIORITY RATINGS - PERIOD 2 (1986-1988)
BASED ON DISTRESS AIR INCIDENTS

-24-

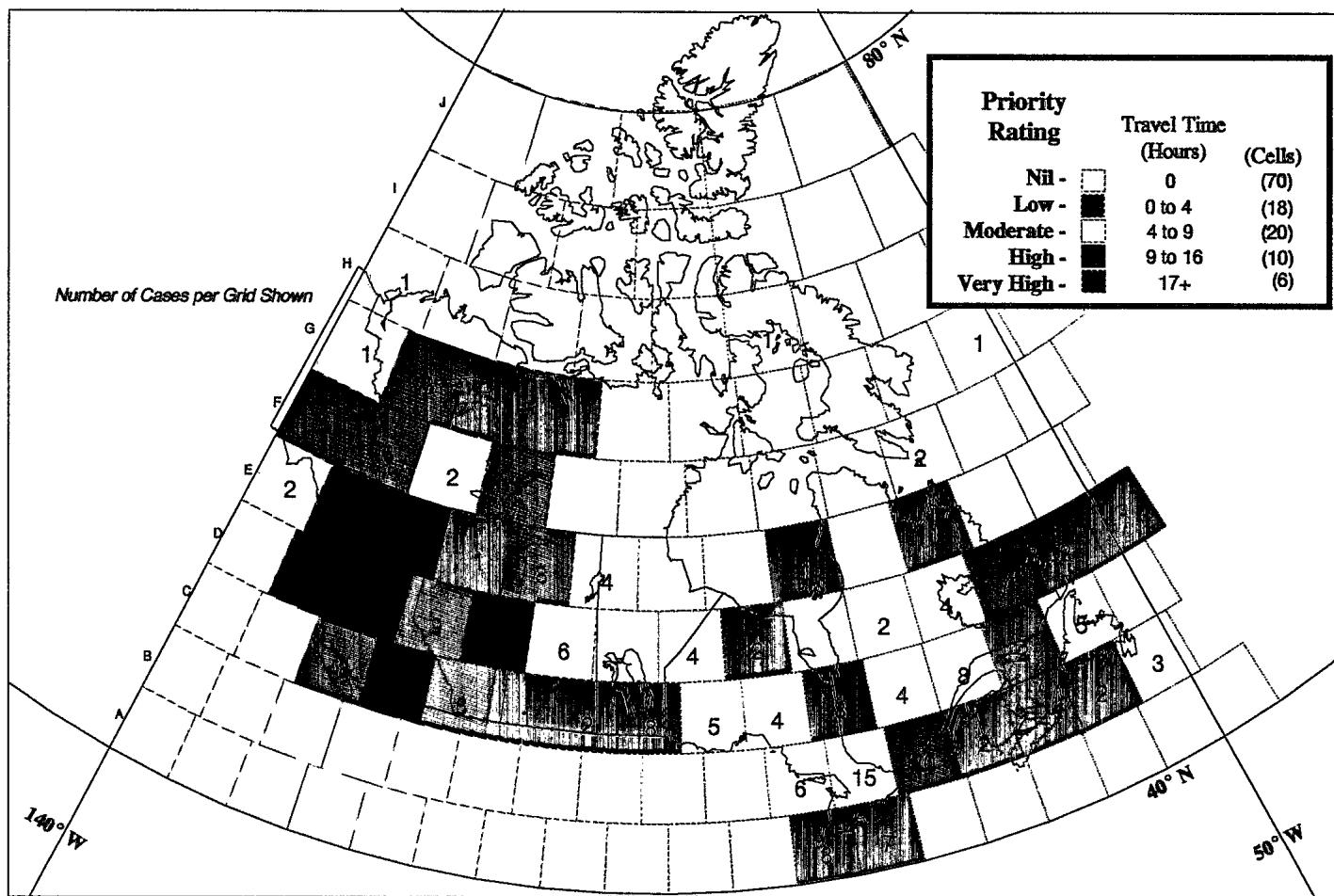


FIGURE 7 : GRID CELL PRIORITY RATINGS - PERIOD 3 (1989-1991)
BASED ON DISTRESS AIR INCIDENTS

PERCEIVED DISTRESS INCIDENTS

62. Three thousand seven hundred fifty-three (3,753) SAR cases qualified as perceived air distress cases. The allocation of the cases among the three time periods is displayed in Table III. The geographic locations of the incidents are shown in Figure 8.

TABLE III : PERCEIVED DISTRESS AIR CASES BY TIME PERIOD

Time Period	Period 1 1983-1985	Period 2 1986-1988	Period 3 1989-1991
Number of SAR Cases	1458	1319	976

63. The SAR incidents were collated with the reference grid cells and total associated travel time was calculated for each time period. Again, for each time period, the grid cells were assigned a priority category based on their relative position within the cumulative frequency distribution of total travel time. The results of the priority category assignment are displayed in Figures 9 through 11.

64. From Table III, the total number of perceived air distress cases decreases in each subsequent time period. The cause(s) for this continuous decrease was not investigated as part of this study. If the reductions are uniformly distributed geographically, as would be expected from a random process, the number of grid cells in the higher priority categories should be reduced in each successive time period. This trend is seen in the Figures.

65. In terms of the general locations of the higher priority areas, there are two distinct regions. The first area includes British Columbia and Alberta; the second region contains the Ontario-Quebec border and part of

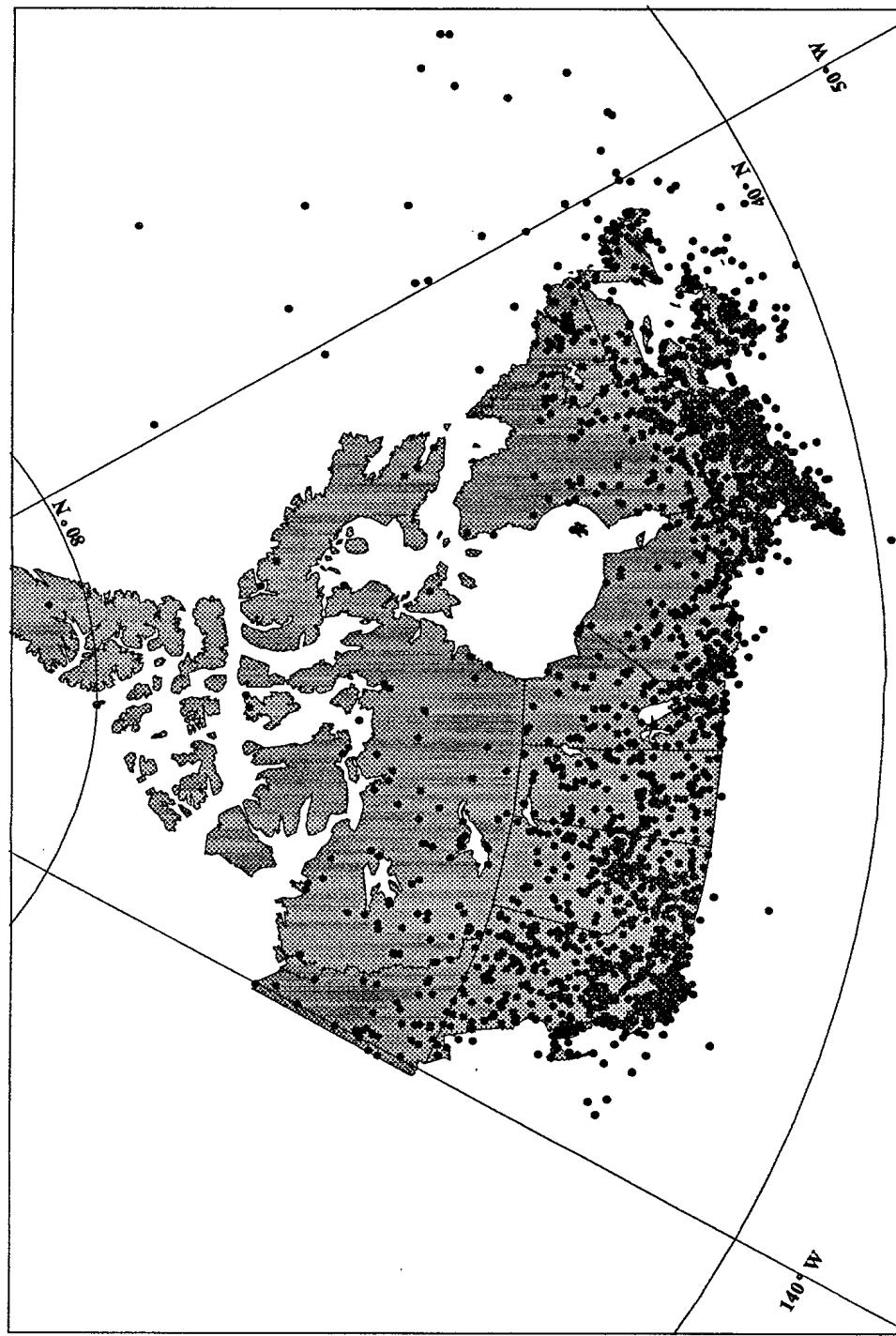


FIGURE 8 : PERCEIVED DISTRESS AIR INCIDENT LOCATIONS (1983-1991)

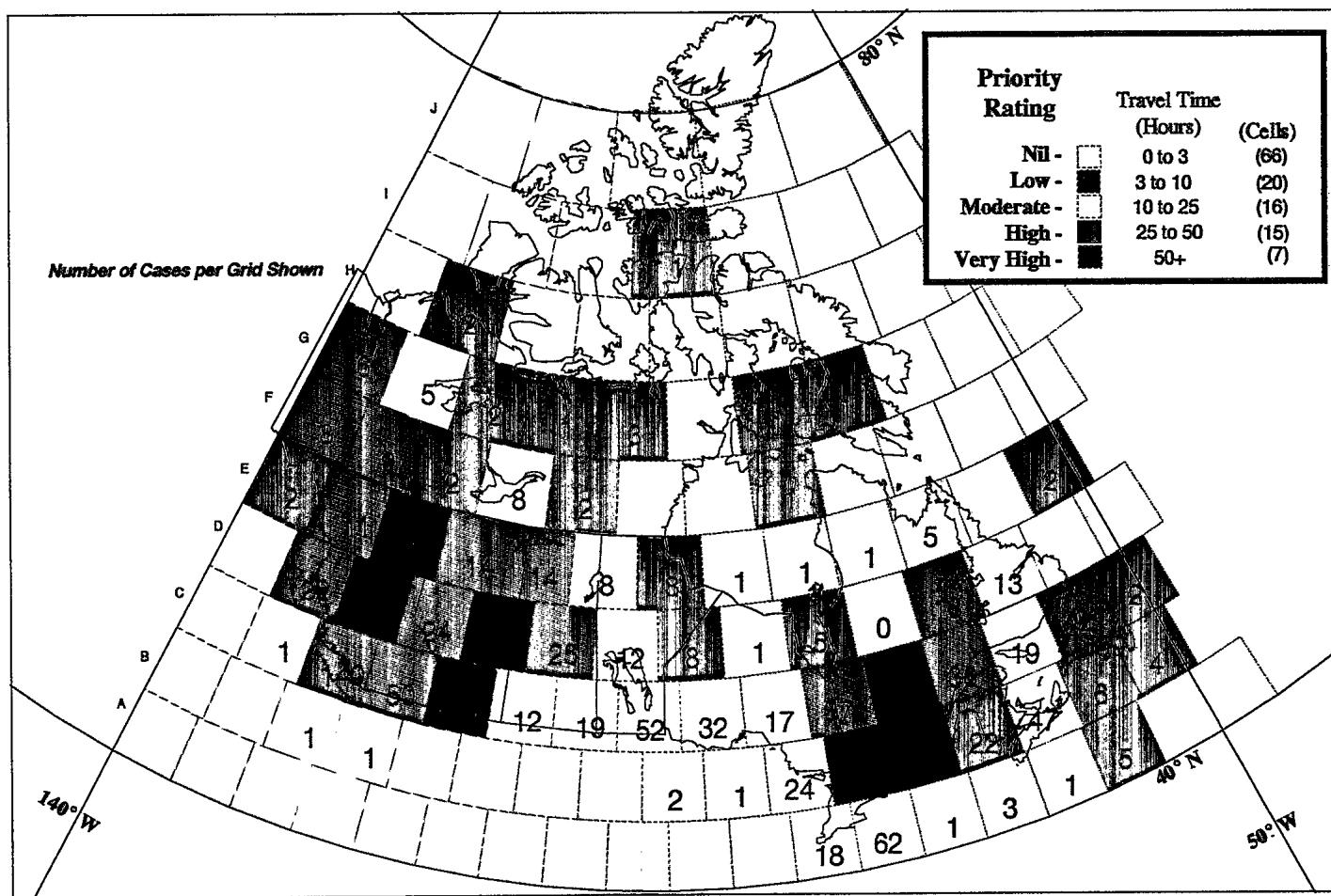


FIGURE 9 : GRID CELL PRIORITY RATINGS - PERIOD 1 (1983-1985)
BASED ON PERCEIVED DISTRESS AIR INCIDENTS

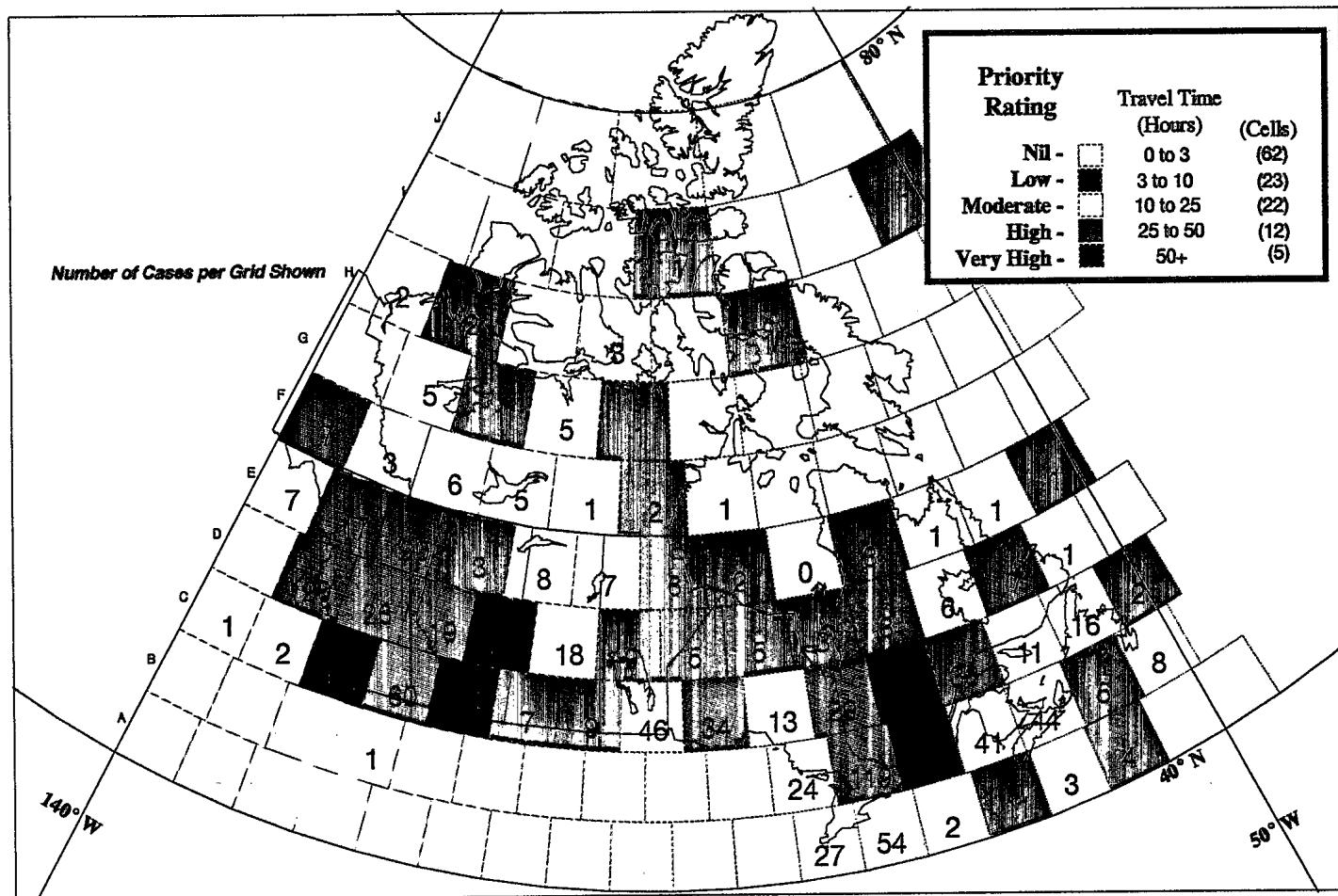
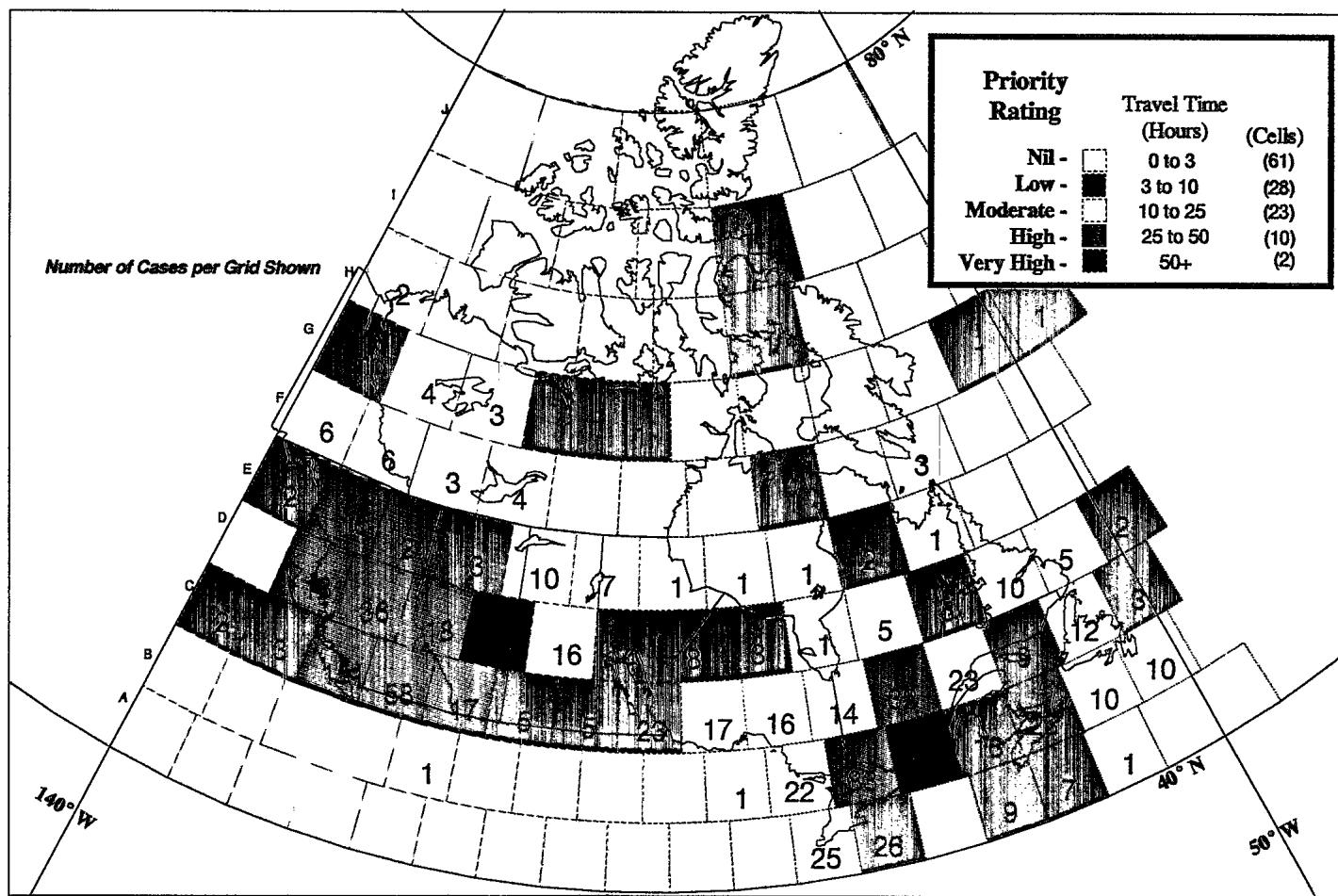


FIGURE 10 : GRID CELL PRIORITY RATINGS - PERIOD 2 (1986-1988)
BASED ON PERCEIVED DISTRESS AIR INCIDENTS



**FIGURE 11 : GRID CELL PRIORITY RATINGS - PERIOD 3 (1989-1991)
BASED ON PERCEIVED DISTRESS AIR INCIDENTS**

- 30 -

southern Quebec. These two areas are consistently the top priority regions in each time period. In the latter time periods, the size of the areas diminishes, as expected given the trend of decreasing case numbers, but the centers of the regions remain relatively fixed.

COMPARISON OF INCIDENT CLASSES

66. The higher priority regions are located in the same approximate areas for both the true distress cases and the perceived distress cases: generally western Canada and southern Quebec. Neither incident class identifies consistent high priority areas in the north nor central Northwest Territories nor central Canada. Similarly, there are no consistent high demand zones located in the Maritimes, for either class of SAR incident.

67. The one significant difference between the geographic distributions of grid cell priority of the true and perceived distress air cases is the SAR demand priority rating of the area around the Yukon Territory. For the true distress incidents, this area was generally rated in the higher priority categories for each of the three time periods. However, several of the individual grid cells show fluctuations in priority rating of several categories over the time periods.

68. For the perceived distress cases, this region in the vicinity of the Yukon Territory is rated as a high priority area in the first time period. In each successive time period, the priority of the region decreases, until in the last time period the area is categorized as moderate and low priority. Given the decrease in the total number of SAR cases associated with the last time period, this transition in priority rating is not unexpected. But, it is a divergence from the results for the true distress incidents.

69. Due to the general similarity in results between the two incidents classes, and the broader statistical basis provided by the perceived distress incident set, it was decided that the pursuant analysis would concentrate only on

the set of perceived distress air cases. This decision was also supported by the consideration that this incident class represented a broader and more realistic requirement for CASARA service.

PRIORITY CONSISTENCY

70. As stated in the previous chapter of this report, temporal consistency was examined from the perspective of retaining a minimum priority rating over the span of the three time periods. A grid cell could attain consistent priority rating by having that priority rating, or a higher rating, in all three time periods. As this evaluation of CASARA coverage was interested in the higher priority regions, the assessment of temporal consistency focused on the high and very high priority categories.

71. Figure 12 shows the locations of the grid cells which had a rating of very high priority in all three time periods. Only two cells satisfied this condition, D5 and B13, located in central Alberta on the Saskatchewan border and in southern Quebec, respectively. When the consistency test is expanded to include both very high and high priority ratings, twelve grid cells satisfy the condition, as shown in Figure 13. The area around cell D5 expands to include all of British Columbia and southern Alberta. The region about cell B13 enlarges by one additional cell to the north and one to the west.

72. Figures 14 and 15 display the results when the temporal consistency criterion is expanded to allow for moderate consistency. Figure 14 shows that for the very high priority category two additional cells, C5 and C12, satisfy the condition for moderate consistency along with the cells passing the test for absolute consistency. In the case of the very high and high priority categories, relaxing the condition from absolute consistency to moderate consistency

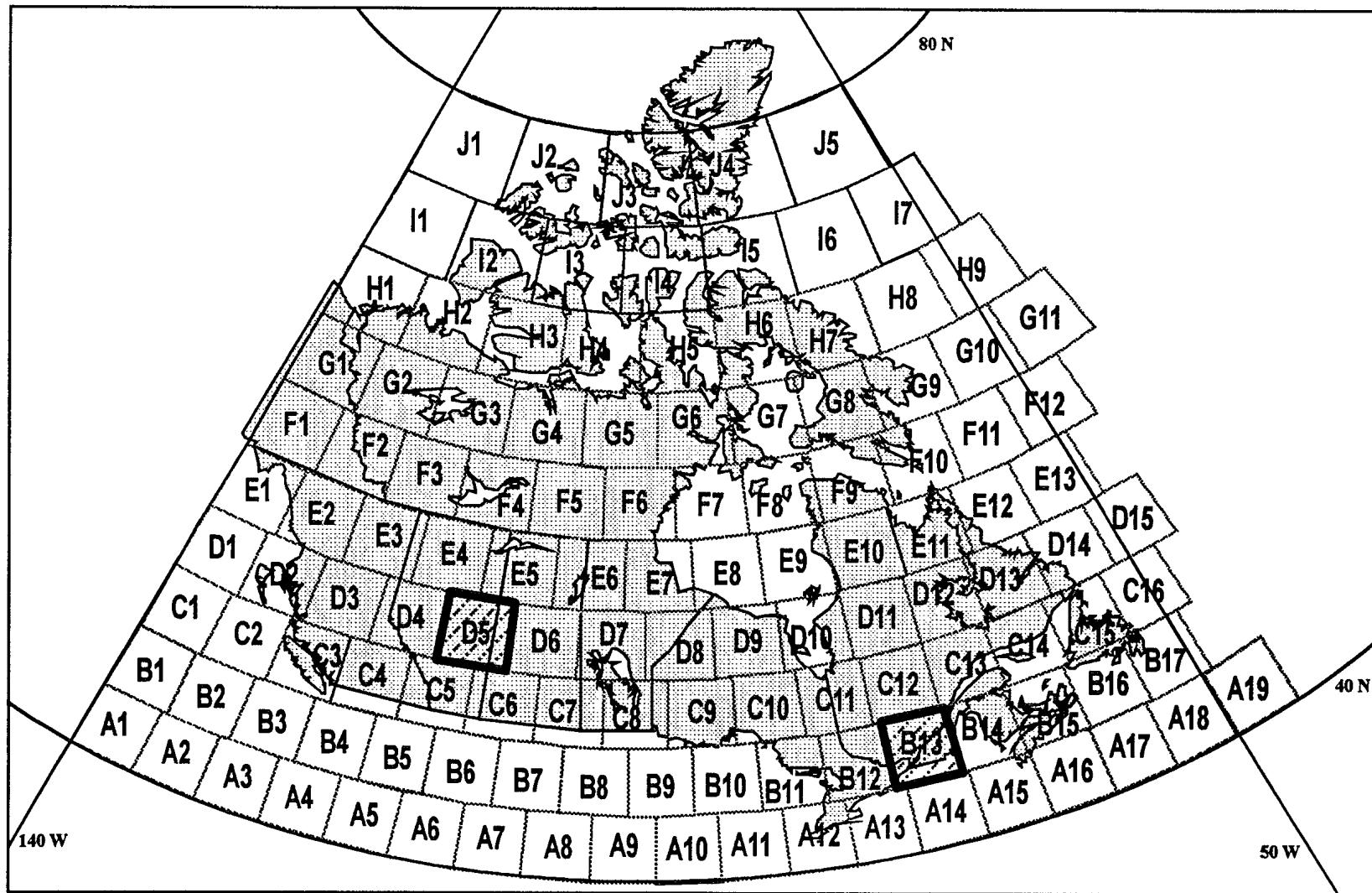


FIGURE 12 : CELLS OF CONSISTENT VERY HIGH PRIORITY
BASED ON PERCEIVED DISTRESS AIR CASES 1983-1991

- 33 -

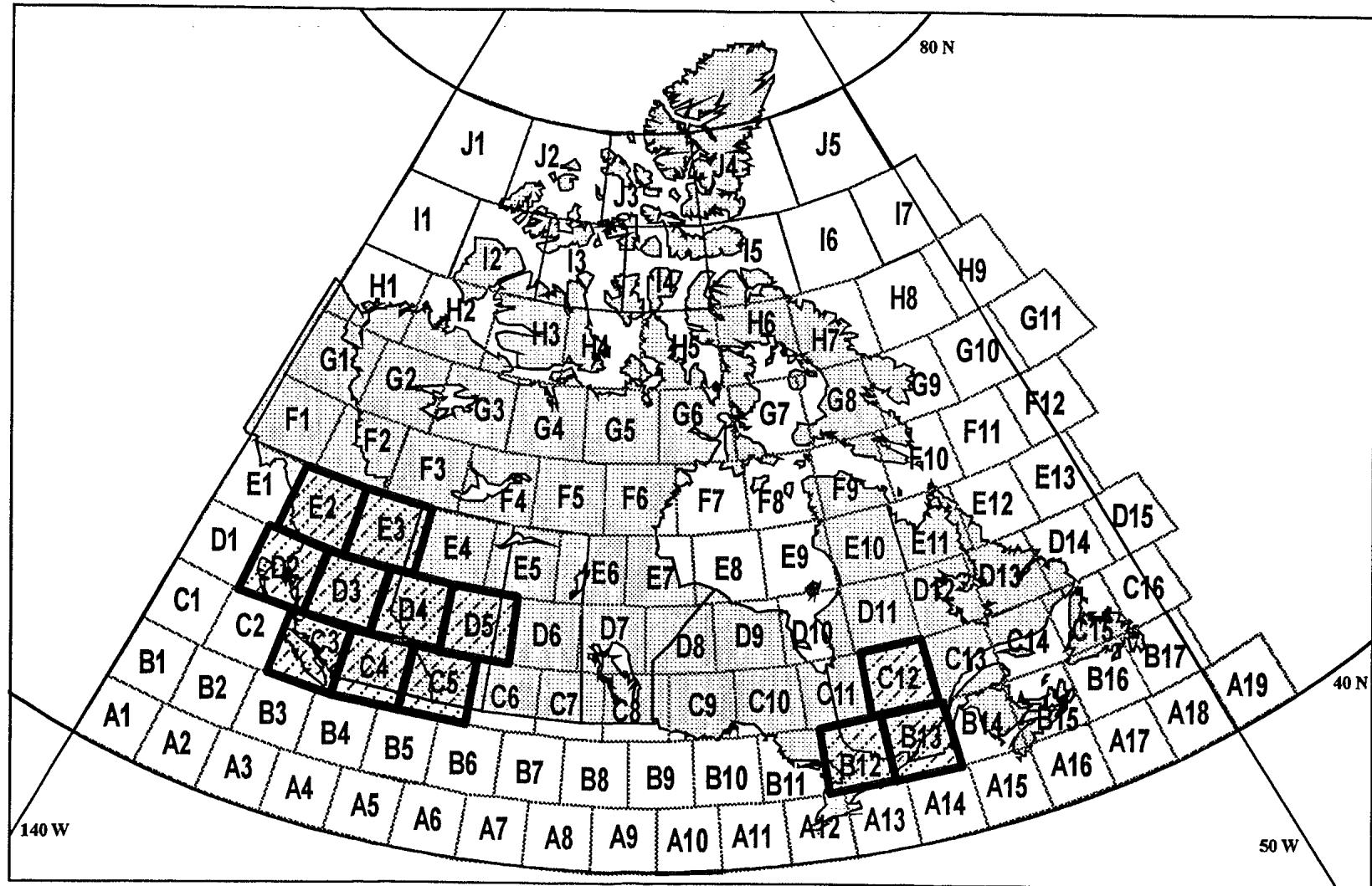
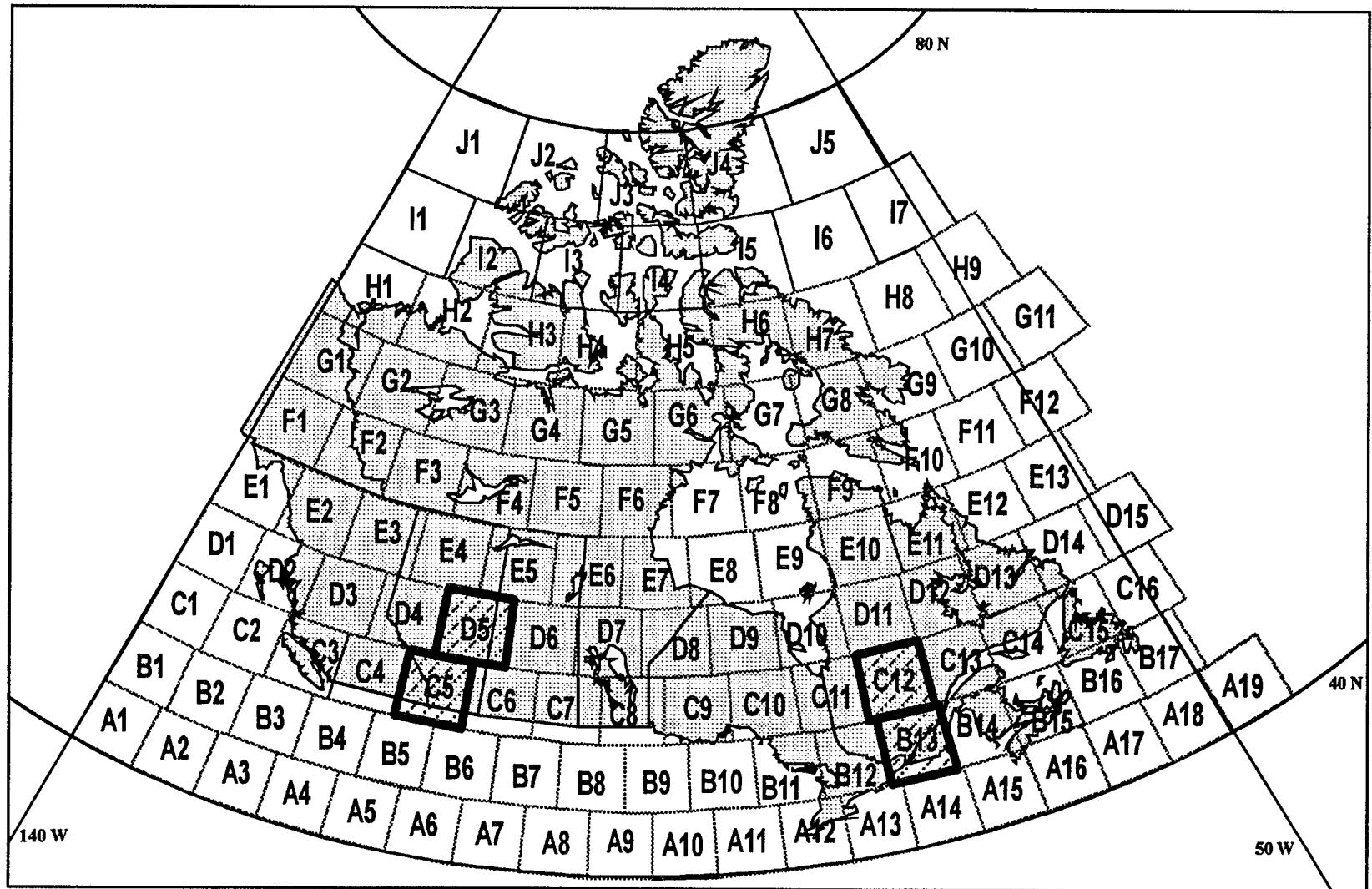


FIGURE 13 : CELLS OF CONSISTENT HIGH OR VERY HIGH PRIORITY
BASED ON PERCEIVED DISTRESS AIR CASES 1983-1991

- 34 -



**FIGURE 14 : CELLS OF MODERATELY CONSISTENT VERY HIGH PRIORITY
BASED ON PERCEIVED DISTRESS AIR CASES 1983-1991**

- 35 -

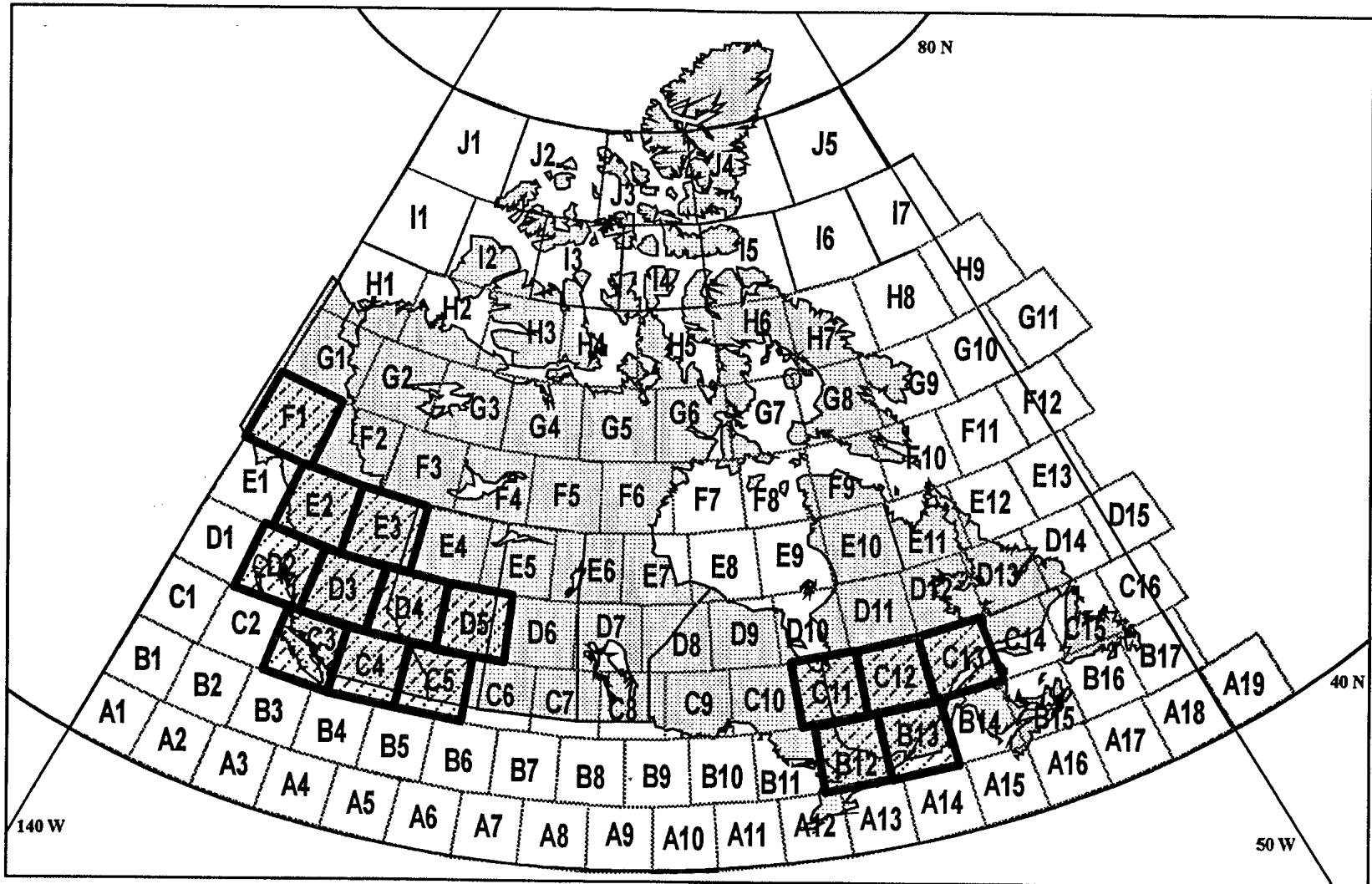


FIGURE 15 : CELLS OF MODERATELY CONSISTENT HIGH OR VERY HIGH PRIORITY
BASED ON PERCEIVED DISTRESS AIR CASES 1983-1991

- 36 -

adds three additional cells to the set. Cell F1, in the Yukon Territory, passes the test for moderate consistency, along with cells C11 and C13 in east central Quebec.

73. As the selection restrictions are relaxed in the transition from absolute (Figures 12 and 13) to moderate consistency (Figures 14 and 15), the two geographic regions meeting the conditions expand in size, i.e., surrounding grid cells are added. However, no new separate areas are identified. The highest priority regions for CASARA service are very localized and stable.

CURRENT CASARA COVERAGE

74. It was assumed that each CASARA unit could provide SAR assistance within a 100 nautical mile zone around its airfield base. Figure 16 displays a cartographic representation of the geographic coverage provided by the present establishment of CASARA units.

75. From the chart, it can be seen that the high population regions of southern Canada are almost completely protected by CASARA coverage. CASARA coverage extends quite a distance north in the central prairie provinces and western Manitoba. The southern half of British Columbia is provided with widespread coverage by CASARA, except for a small gap in the center of the coverage pattern. The Yukon Territory, Northwest Territories, northern B.C., northern Ontario, and northern Quebec have large areas devoid of CASARA coverage.

76. Without making any judgements regarding the maximum overlap in coverage that is desirable between units, it is noted that there are several geographic regions that do appear to have exceptionally high levels of overlap in CASARA unit coverage. In particular, the southern prairie provinces, the Ottawa to Quebec City corridor in southern Quebec, and area around Nova Scotia have a high density of CASARA coverage.

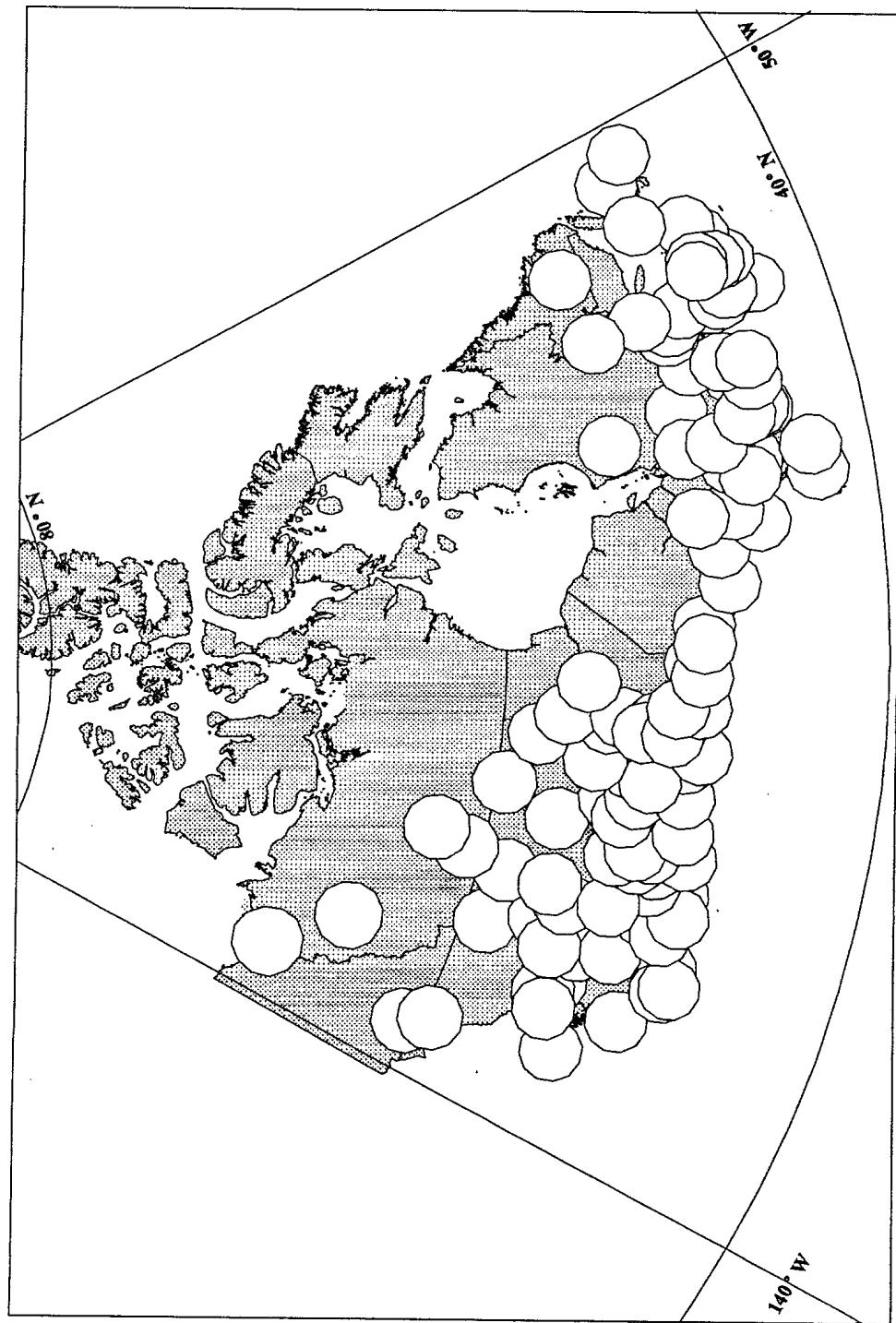


FIGURE 16 : CASARA GEOGRAPHIC COVERAGE

77. The co-location of CASARA unit coverage with the consistent high demand areas occurs to a large extent. The high demand zones located in southern British Columbia (cells C3, C4, C5, D2, D3, D4, and D5) are for the most part blanketed by CASARA coverage. Likewise, the high demand areas in southern Ontario and the St. Lawrence Seaway (cells B12, B13, and C13) are almost entirely provided with CASARA coverage.

78. There are some high demand areas that are not covered by CASARA units. The region around northern British Columbia and the southern Yukon Territory lacks CASARA coverage, as does the area in south central Quebec. There is also a gap in coverage in the high demand region south of Hudson Bay, near the Quebec-Ontario border.

SAR DEMAND BEYOND CASARA COVERAGE

79. To identify areas offering the greatest potential for CASARA coverage enhancement, the SAR demand outside of current CASARA coverage was assessed. SAR cases located within CASARA coverage were removed from the set of perceived distress air incidents. Figure 17 shows the geographic distribution of the SAR incidents beyond CASARA coverage. Travel times for each grid cell were recalculated from the revised data set and priority ratings for the grid cells were renormalized based on the modified cumulative frequency distribution.

80. Figures 18 to 20 display the SAR demand priority rating of each grid cell for the three time periods, respectively. As expected, the area of northern B.C., and the Yukon Territory is rated as a very high priority in several of the time periods. Also, as anticipated, the areas south of Hudson Bay and in central Quebec are given high priority ratings.

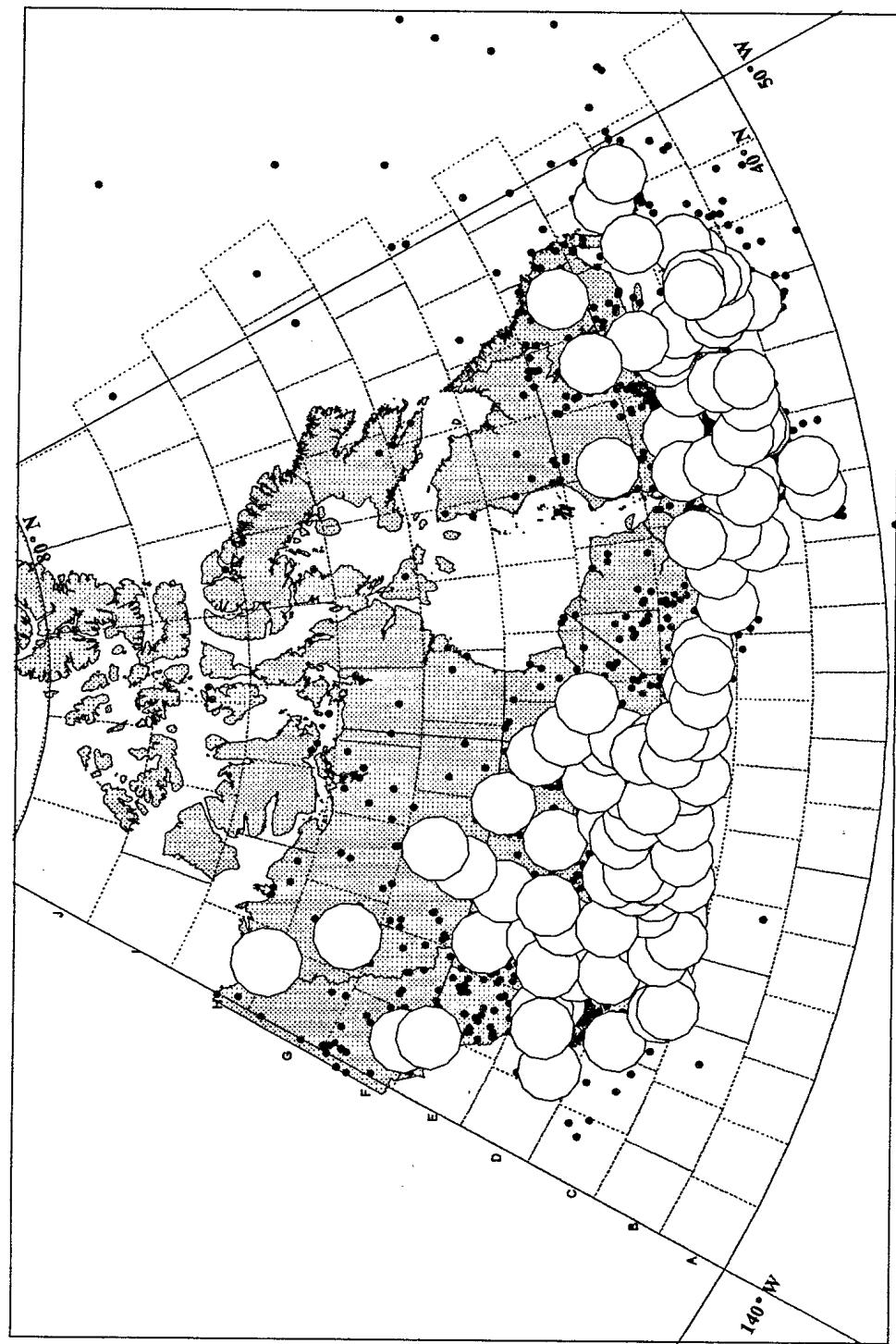


FIGURE 17 : PERCEIVED DISTRESS AIR INCIDENTS BEYOND CASRARA COVERAGE (1983-1991)

- 40 -

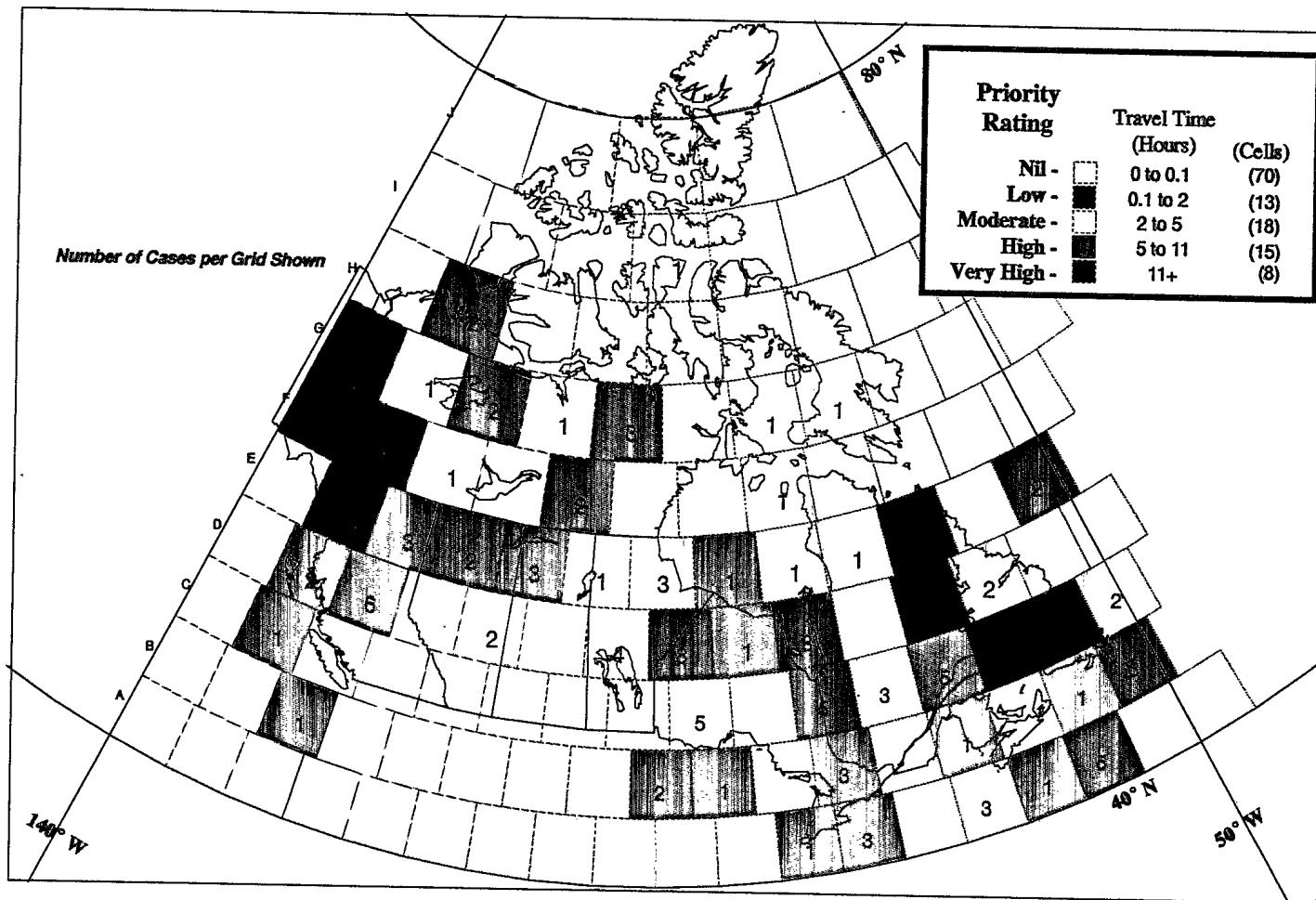
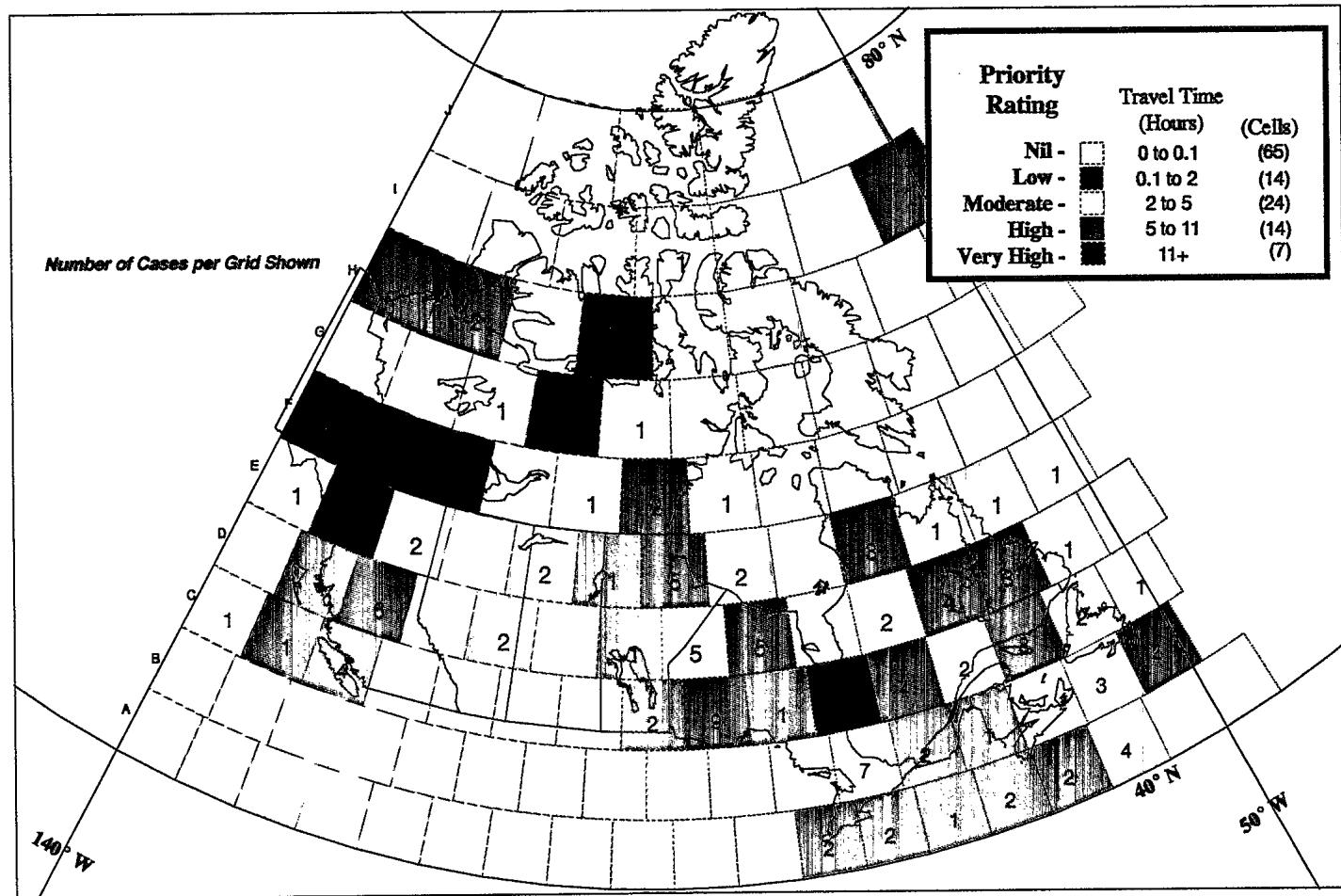


FIGURE 18 : GRID CELL PRIORITY RATINGS - PERIOD 1 (1983-1985)
BASED ON PERCEIVED DISTRESS AIR INCIDENTS BEYOND CASARA COVERAGE



- 41 -

FIGURE 19 : GRID CELL PRIORITY RATINGS - PERIOD 2 (1986-1988)
BASED ON PERCEIVED DISTRESS AIR INCIDENTS BEYOND CASARA COVERAGE

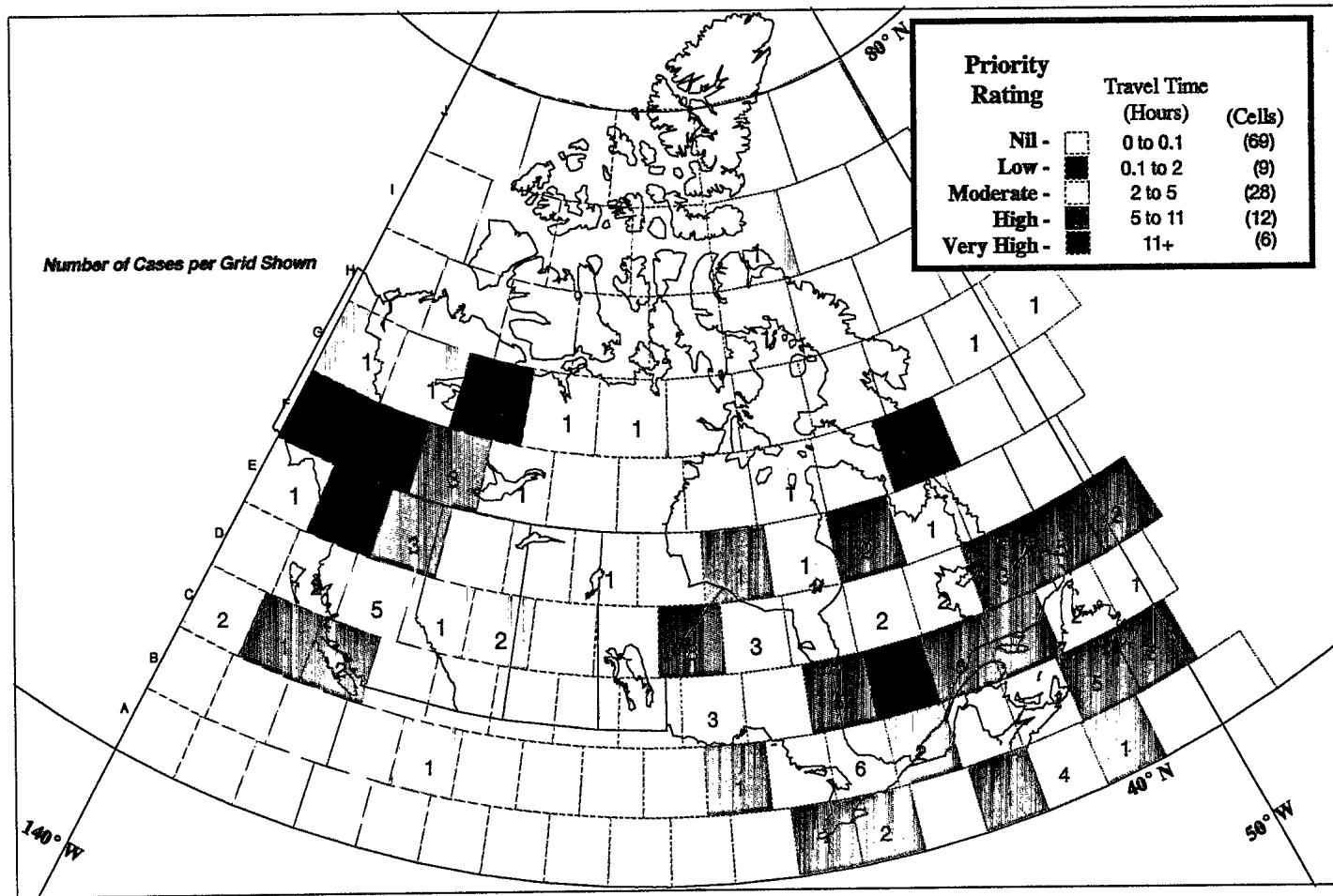


FIGURE 20 : GRID CELL PRIORITY RATINGS - PERIOD 3 (1989-1991)
BASED ON PERCEIVED DISTRESS AIR INCIDENTS BEYOND CASARA COVERAGE

- 43 -

81. With the revised ratings, new areas emerge with high SAR demand priority designations. The northern Yukon Territory, western Northwest Territories, eastern Quebec, Labrador, and the areas around Newfoundland appear as very high priority zones in some of the time periods.

BEYOND-COVERAGE SAR DEMAND CONSISTENCY

82. Figures 21 to 24, display the outcome of applying the temporal consistency tests to the revised demand priority results. Only the areas of northern British Columbia and the southern Yukon Territory (cells F1, F2, and E2) qualify as consistent very high priority. When the high priority category is included in the test for absolute consistency, the area south of Hudson Bay and two areas bordering on Newfoundland (see Figure 22) qualify, in addition to the previously identified areas.

83. When the consistency restriction is eased to moderate consistency, and the priority category is restricted to very high priority, no new areas are added to those passing the test for absolute consistency. Testing for moderate consistency and very high or high priority, qualifies several new areas (see Figure 24). Qualifying areas appear in northern and central B.C., the western Northwest Territories, the Ontario-Manitoba border, central and northern Quebec, and Labrador. The number of grid cells passing the test nearly triples compared to the situation for absolute consistency.

REGIONAL PRIORITIZATION FOR CASARA DEVELOPMENT

84. The consistency results provide a general indication of where attention should be focused for the development of future CASARA units. Funding for the establishment of new CASARA units is likely to be limited, such that it will not be possible to provide financial

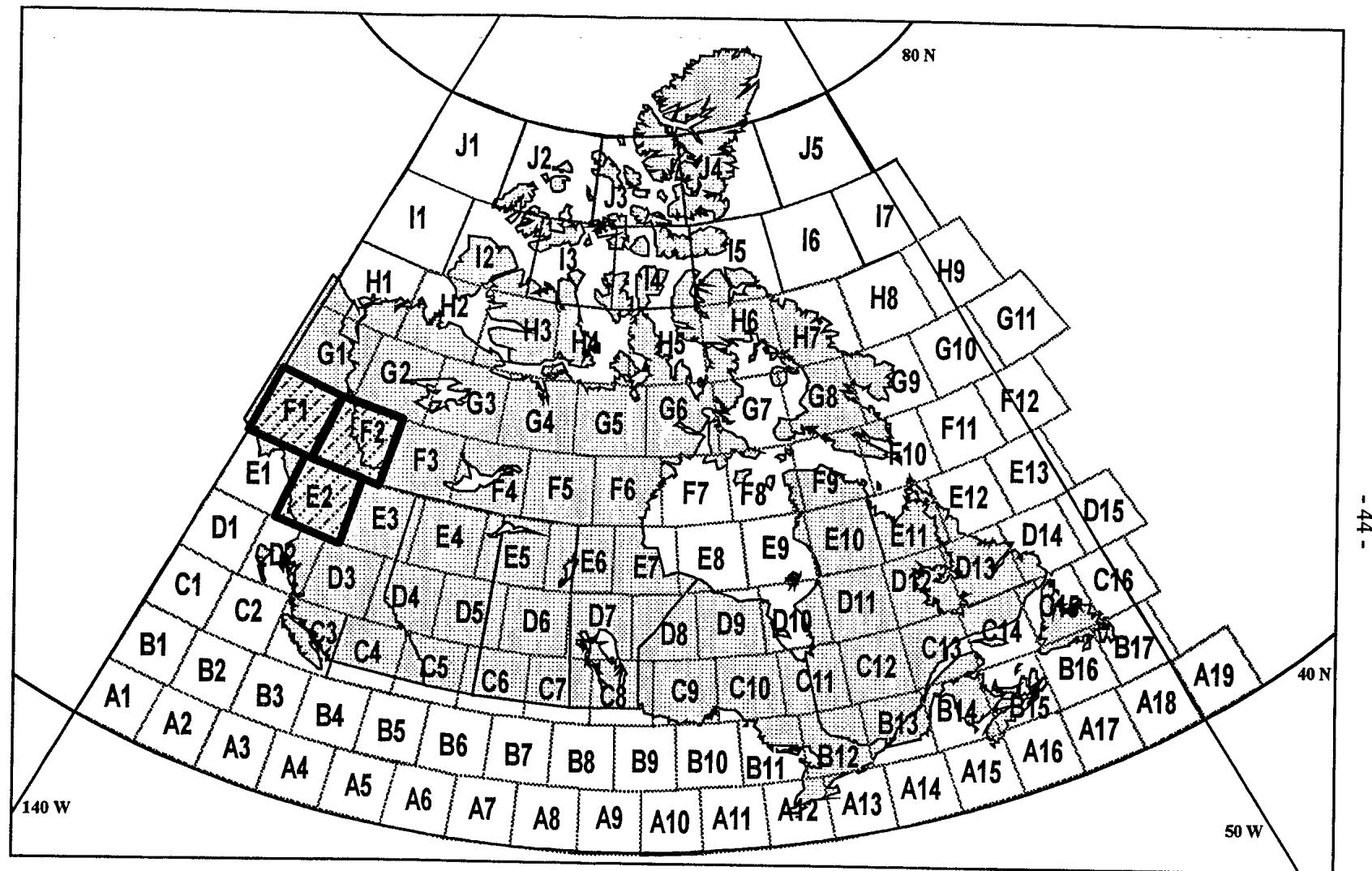


FIGURE 21 : CELLS OF CONSISTENT VERY HIGH PRIORITY BASED ON PERCEIVED DISTRESS AIR CASES BEYOND CASARA COVERAGE 1983-1991

- 45 -

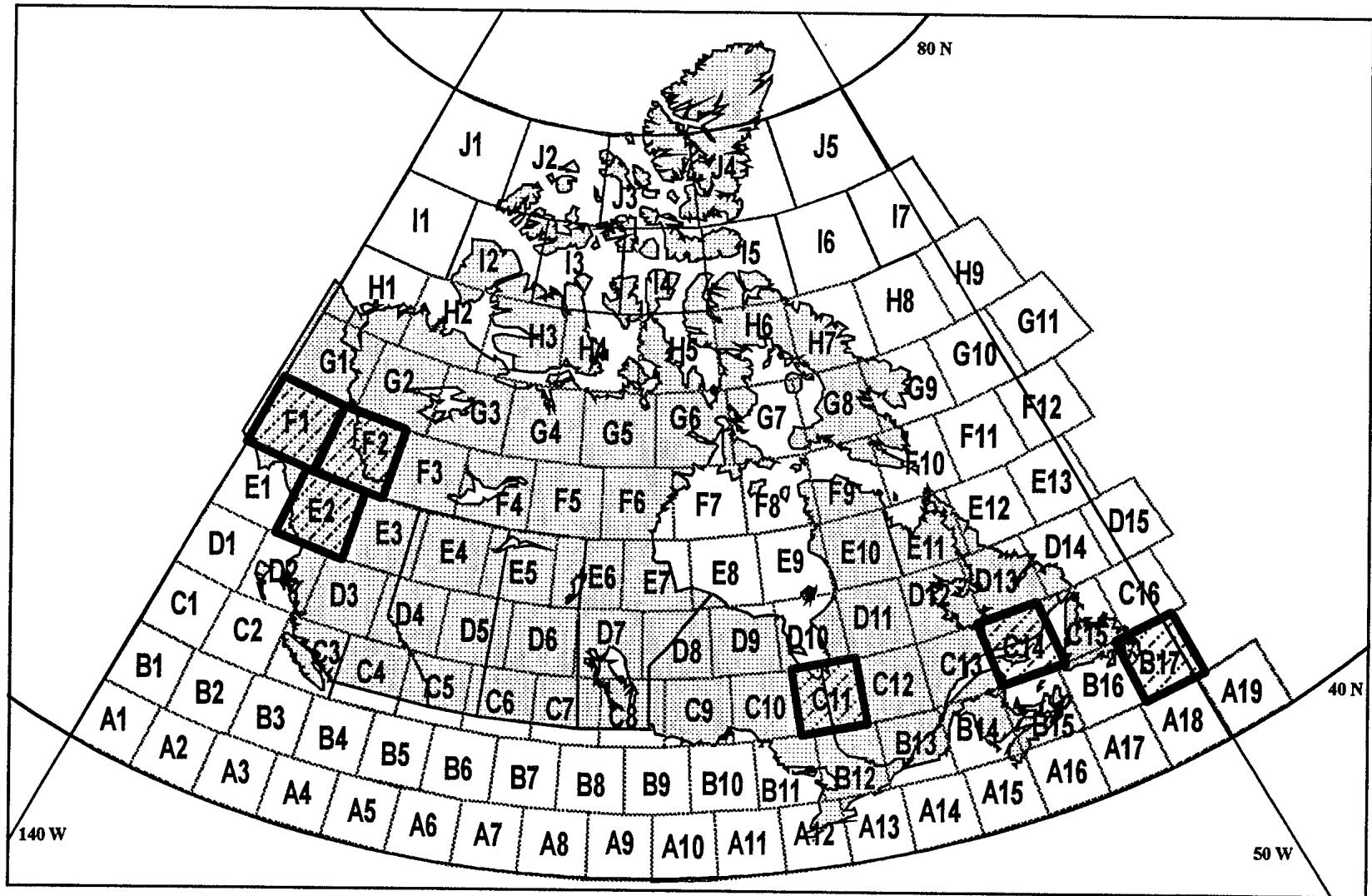


FIGURE 22 : CELLS OF CONSISTENT HIGH OR VERY HIGH PRIORITY BASED ON PERCEIVED DISTRESS AIR CASES BEYOND CASARA COVERAGE 1983-1991

- 46 -

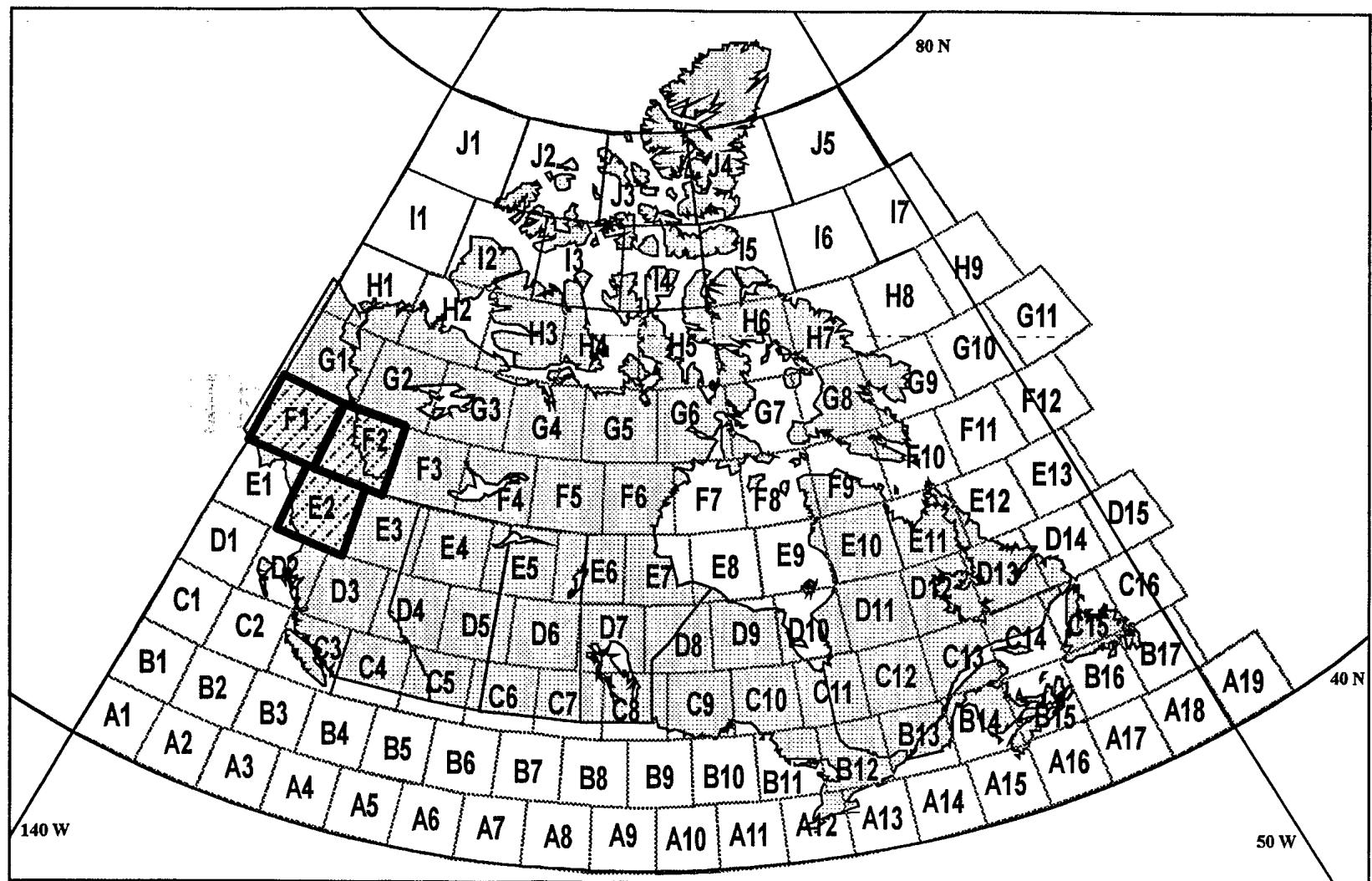


FIGURE 23 : CELLS OF MODERATELY CONSISTENT VERY HIGH PRIORITY BASED ON
PERCEIVED DISTRESS AIR CASES BEYOND CASARA COVERAGE 1983-1991

- 47 -

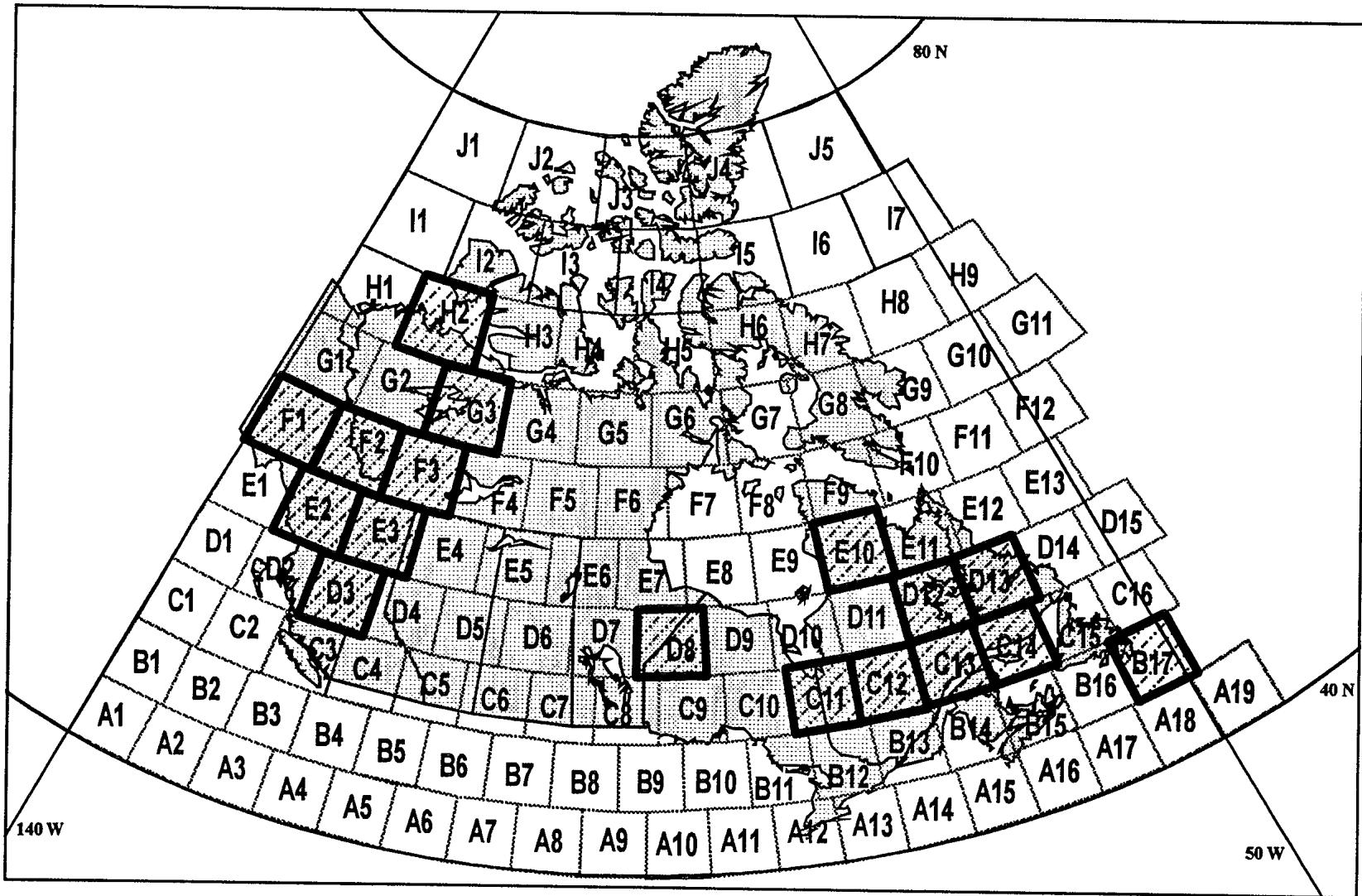


FIGURE 24 : CELLS OF CONSISTENT HIGH OR VERY HIGH PRIORITY BASED ON
PERCEIVED DISTRESS AIR CASES BEYOND CASARA COVERAGE 1983-1991

- 48 -

support to all the regions where CASARA development is desirable. Under such circumstances, it is useful to perform an evaluation to determine the relative priority of each area for future CASARA development.

85. Two factors were deemed to be very important when prioritizing areas for future development. The magnitude of the SAR demand (total travel time) and the consistency of the demand must be included in the assessment. The magnitude of the demand is important because new CASARA units should be located where they will provide the greatest benefit to the SAR system. Consistency of demand is critical to ensure that unit motivation and level of readiness are maintained, through routine operation.

86. In prioritizing regions, a balance must be established between total demand and consistency. It was felt that a very logical approach to achieve this balance was to weigh total travel time by the proportion of time periods over which the demand is distributed. A grid cell with non-zero travel time for only one of the three time periods would have the travel time modified by a factor of one third. A cell with two time periods of non-zero travel time would have the sum of the travel times multiplied by a factor of two thirds. Three time periods of non-zero travel time would yield a modifying factor of unity. Applying this procedure would ensure that regions with high constant demand would be given higher priority than regions with slightly greater, but more sporadic, demand.

87. The results of the application of this prioritization method are listed in Table IV. The rank indicates the relative priority of the grid cell for consideration of future CASARA development. The score is the parameter used to rank the grid cells and can be considered as a measure of the gap in relative benefit between cells of different rank. For example, the top priority region for CASARA development is grid cell E2, while the second priority area is cell F2. While the rank of these two cells is very close, the scores are quite different, 93.8 vice

- 49 -

59.1. By the ranking method used, it would be almost twice as important or useful to establish a CASARA unit in cell E2 as in cell F2.

88. The relative scores for the grid cells are useful when considering factors important to unit development other than demand and consistency. Areas which are relatively close in terms of their scores may be reordered in terms of priority when considering other factors such as ease of unit development or unit operations costs.

89. Figure 25 displays the locations of the grid cells ranked in the top 20 positions for priority. Not surprising, most of the cells are located in the regions identified in the simple consistency tests.

90. Two other rank ordering methods were applied, to the grid cell travel time data for SAR cases beyond CASARA coverage, to assess the robustness of the solution. One method utilized scores based on the priority categories of the grid cells, while the other method used a bell curve approach. Details of these methods were covered in the previous chapter of this report. While both methods possess merit, they were felt to be somewhat inferior to the ranking method reported above.

91. Detailed results will not be reported for these two alternate methods. However, a comparison of the grid cells identified in the top 15 rank positions was performed. Among the three ranking models, there was agreement for 13 grid cells identified in the first 15 rank positions. The other cells, in the first 15 positions which lacked complete agreement among the ranking models, were positioned within the next five rank levels, in all cases. These results provide confidence that the grid cell prioritization solution reported is robust.

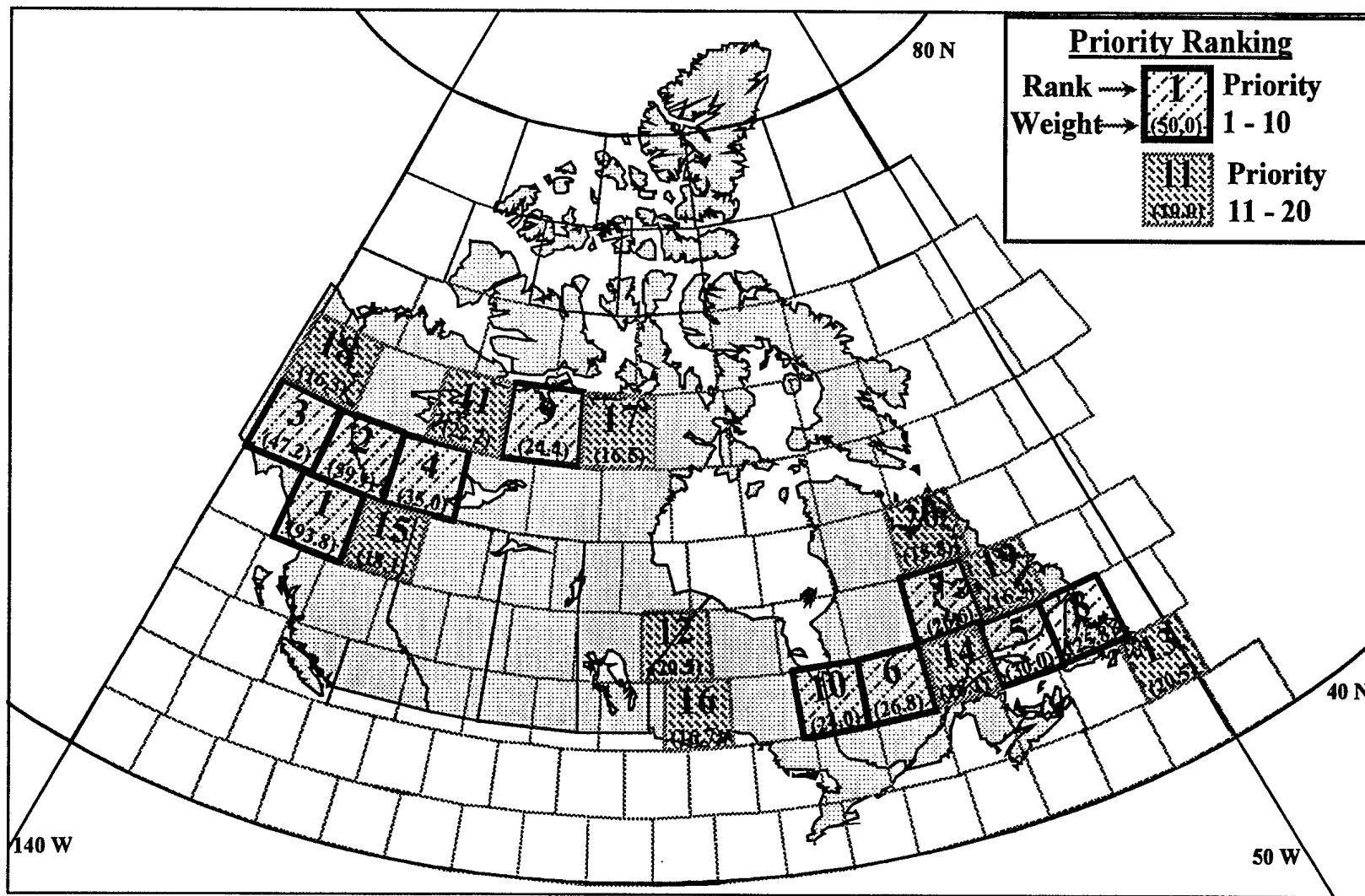
**TABLE 4 : GRID CELL PRIORITY RANKING BASED ON PERCEIVED DISTRESS AIR CASES
BEYOND CURRENT CASARA COVERAGE 1983-1991**

Rank	Cell	Score
1	E2	93.810
2	F2	59.100
3	F1	47.180
4	F3	34.990
5	C14	29.960
6	C12	26.820
7	D12	26.590
8	C15	25.790
9	G4	24.430
10	C11	23.980
11	G3	22.220
12	D8	20.540
13	B17	20.500
14	C13	18.140
15	E3	18.110
16	C9	16.730
17	G5	16.530
18	G1	16.327
19	D13	16.290
20	E11	15.810
21	E10	15.240
22	D3	14.400
23	D9	13.590
24	D5	13.170
25	A17	12.580
26	H2	12.140
27	B16	10.920
28	E7	8.593
29	C16	8.330
30	D14	8.253
31	D2	6.970
32	E13	6.833
33	E8	6.590
34	E5	6.387
35	I4	6.353
36	E6	6.130
37	G2	5.987
38	H6	5.907
39	D11	5.367
40	B12	5.320
41	F5	4.993

Rank	Cell	Score
42	A16	4.730
43	E1	4.700
44	F8	4.220
45	A15	3.870
46	C1	3.853
47	H4	3.830
48	F10	3.697
49	A12	3.660
50	E9	3.587
51	C2	3.320
52	B13	2.333
53	D7	2.113
54	I7	2.027
55	C3	2.013
56	H1	1.833
57	D15	1.823
58	A13	1.770
59	E4	1.690
60	D10	1.673
61	F6	1.667
62	I5	1.607
63	G11	1.593
64	G10	1.467
65	B10	1.340
66	G8	1.310
67	G7	1.090
68	F4	1.047
69	E12	0.940
70	F7	0.880
71	B14	0.820
72	B5	0.803
73	D4	0.747
74	B9	0.503
75	C10	0.420
76	B3	0.367
77	C8	0.323
78	A14	0.130
79	A1	0.000
80	A10	0.000
81	A11	0.000
82	A18	0.000

Rank	Cell	Score
83	A19	0.000
84	A2	0.000
85	A3	0.000
86	A4	0.000
87	A5	0.000
88	A6	0.000
89	A7	0.000
90	A8	0.000
91	A9	0.000
92	B1	0.000
93	B11	0.000
94	B15	0.000
95	B2	0.000
96	B4	0.000
97	B6	0.000
98	B7	0.000
99	B8	0.000
100	C4	0.000
101	C5	0.000
102	C6	0.000
103	C7	0.000
104	D1	0.000
105	D6	0.000
106	F11	0.000
107	F12	0.000
108	F9	0.000
109	G6	0.000
110	G9	0.000
111	H3	0.000
112	H5	0.000
113	H7	0.000
114	H8	0.000
115	H9	0.000
116	I1	0.000
117	I2	0.000
118	I3	0.000
119	I6	0.000
120	J1	0.000
121	J2	0.000
122	J3	0.000
123	J4	0.000
124	J5	0.000

- 51 -



**FIGURE 25 : REGIONAL PRIORITY RANK ORDER (1 TO 20) FOR CASARA UNIT DEVELOPMENT
BASED ON PERCEIVED DISTRESS AIR CASES 1983-1991**

IV. CONCLUSIONSPRESENT CASARA COVERAGE

92. The current configuration of CASARA units provides considerable coverage across the country at the southern latitudes. Complete provincial coverage is present in Alberta, Saskatchewan, and the maritime provinces. A high proportion of the provincial region is provided with support in British Columbia and Manitoba. Northern Ontario, northern Quebec, Labrador, the Yukon Territory, and the Northwest Territories have minimal CASARA coverage.

93. Comparing the regions of greatest demand for SAR service with the area coverage provided by CASARA, it can be seen that most, but not all, of these high demand areas are provided with CASARA support.

94. There is a significant variation in the density of CASARA coverage, in the regions where it is provided. There are zones with little overlap in coverage between CASARA units, and other areas where the overlap in unit coverage is extremely high. While it is important to note that this variation in coverage density exists, this study did not attempt to assess the consequences or significance of this situation.

95. The reader is cautioned about drawing any conclusions regarding the suitability of the overlap in coverage among CASARA units. It should be remembered that all units were treated equally in this study. Every unit was assumed to have a 100 nautical mile radius of operation. In reality, there are considerable differences between units, in terms of the number of volunteers, availability of aircraft, level of readiness, etc. Considering the volunteer nature of the CASARA organization, some degree of overlap between units is desirable.

HIGH PRIORITY REGIONS

96. This study has shown that there are a number of areas placing high demands on DND SAR resources, which lie outside of the current CASARA coverage area. In particular, the area of northern British Columbia and southern Yukon Territory is a region with high demand and low coverage. The area south of Hudson Bay is another region with this characteristic.

97. From a perspective of continuous improvement, the grid areas forming the region of Canadian SAR interest were evaluated, based on SAR demand currently beyond CASARA coverage, to determine the most beneficial locations to establish new CASARA units. Priority was given to areas with high consistent demand. Each grid cell was scored and ranked according to the potential benefits of locating a unit there.

98. The region of highest priority for the establishment of CASARA units is the area in northern British Columbia and the south Yukon Territory, extending to the adjoining corner of the Northwest Territories. The second highest priority region is central Quebec extending, in latitude, from the Ontario border to the mouth of the St. Lawrence River to the area around Newfoundland. Of high, but somewhat lesser, priority is an area along the Manitoba-Ontario border. An area of similar priority was identified north of Great Slave Lake in the Northwest Territories, extending east from Great Bear Lake.

99. These regions were assessed as offering the greatest potential return on investment for the establishment of new CASARA units. When considering the formation of new CASARA units, the aforementioned regions should be given top priority.

ADDITIONAL FACTORS

100. This study prioritized regions for the future establishment of new CASARA units, entirely from the perspective of demand for service. While this is a very important factor in the selection of areas for new development, it is not the only important consideration. Discussions with the CASARA National Administrator (Ref. 7), pointed out that there are many other factors that must be examined before choosing a particular region to concentrate efforts to establish a new unit.

101. The existence of a suitable airfield in the region is an overriding consideration. Irrespective of demand, it is obvious that the lack of an acceptable airfield will preclude the establishment of a CASARA unit. Similarly, the presence of an organized flying club in the region greatly facilitates the process to establish a CASARA unit. The numbers of members and aircraft are also important considerations. As well, the club's level of interest in becoming a CASARA unit is another significant factor to examine.

102. With the limited resources available, all factors affecting the potential for success in establishing a CASARA unit must be considered along with the assessment of demand for the service in the region.

RECOMMENDATIONS

103. Expanding Assessment Basis. This study has produced a priority ranking of regions for the future formation of CASARA units based on the demand for SAR service. The additional factors noted above should be assessed for each of these regions. The results from the assessment of the factors relating to the potential for unit establishment should be merged with the results of this study. A final ranking of region priority should be produced, based on SAR demand and CASARA unit formation

potential. It is recommended that this action be initiated by senior SAR management.

104. Expansion of the evaluation to include these additional factors may require substantial revision and modification of the assessment methodology. It is suggested that this action, if undertaken, be performed in cooperation with the CASARA organization.

105. Coverage Density Assessment. A high variability in CASARA coverage density was identified. It was beyond the scope of this study to assess the impact to effectiveness and efficiency of the current network of CASARA units. A study should be undertaken to investigate the most effective level of unit coverage density and identify an optimum set of CASARA units. It is recommended that such a study be initiated by senior SAR management.

106. The OR division has completed a number of studies which examined the optimal allocation of bases for SAR (Ref. 8, 9, and 10). These studies identified optimization procedures for the selection of unit bases from among a set of possible candidate locations. The optimization models developed in References 8, 9, and 10 could be adapted to evaluate the current distribution of CASARA unit locations and propose changes to improve effectiveness.

107. Future Evaluations. The methodology developed for this evaluation of future sites for CASARA unit formation is suitable for continual application. As additional data on SAR incidents become available, the method could be reapplied to determine the new priority ranking for potential CASARA sites. The continual expansion of the data set would increase the statistical significance and raise the level of confidence of the results. Periodic reassessment of SAR demand and regional priority would allow the impact of changes in SAR demand to be evaluated.

- 56 -

108. In the near future, it is expected that DND will have complete and convenient access to the SAR data in the Coast Guard database, covering the years 1992 onward. It is recommended that DGOR be tasked to expand this study to include these data, when access becomes available.

REFERENCES

1. Moscrip J.G., OPTIMUM LOCATIONS FOR CIVIL SEARCH AND RESCUE SQUADRONS, DAOR Staff Note 76/6, March 1976
2. Christopher G.L. and R.L. Roy, Operational Research Support to Search and Rescue (1974-1995), Briefing to National Search and Rescue Secretariat Executive Staff and Air Command Ottawa Office, August 1995
3. Memorandum, 3385-10-4 (SSO SAR), 6 September 1995
4. Easton G.D., GEOGRAPHIC DISTRIBUTION OF SAR DISTRESS INCIDENTS - QUEBEC AND MARITIMES, DAOR Staff Note 82/4, June 1982
5. Fitch, F., M. Halbrohr and Capt Petit-Pas, SEARCH AND RESCUE HELICOPTER CAPABILITY REQUIREMENTS, DAOR Project Report PR520, September 1990
6. Where and When Incidents Occur, National Search and Rescue Secretariat, NSS-SARAMI04-01-E, February 1994
7. Discussions with Mr R. Kilborn, CASARA National Administrator, AIRCOM HQ, December 5 1996
8. O'Neill, Philip F., OPTIMAL LOCATION OF HELICOPTER BASES FOR SEARCH AND RESCUE, DAOR Staff Note 19/88, February 1988
9. O'Neill, Philip F., OPTIMAL LOCATION OF CASARA, DAOR Staff Note 20/88, January 1988
10. Christopher, G.L., A NEW MODEL FOR ALLOCATING SEARCH AND RESCUE BASES, ORA Project Report PR 652, October 1993

ANNEX A
TO PROJECT REPORT PR 9610
DATED APRIL 1996

Search Subroutines to Select Incidents

1. Incidents for the CASARA Basing Study were selected from the SARSTATS (1983-87) and SARIS (1988-91) database according to the following criteria:

SARSTATS Air Distress Case

- IncidentClass A (air)

and one of the following conditions:

- Incident category 1 (distress with primary SAR tasked) or 2 (distress no primary SAR tasked)
- Person Fatal greater than 0
- Persons Missing greater than 0

SARSTATS Perceived Air Distress Case

- Incident Class A (air)

and one of the following conditions:

- Incident category 1 (distress with primary SAR tasked) or 2 (distress no primary SAR tasked)
- Person Fatal greater than 0
- Persons Missing greater than 0
- Resource Count and Resouce Agency DND

SARIS Distress Air Case

- Incident Class 01 (air)

and one of the following conditions:

- Closing Highest Urgency 1
- Closing Life at Risk Y (yes)
- Closing Lost greater than 0
- Closing Not Located greater than 0

SARIS Perceived Air Distress Case

- Incident Class 01 (air) or 06 (beacon)

and one of the following conditions:

- Closing Highest Urgency 1 (distress)
- Closing Life at Risk Y (yes)
- Closing Lost greater than 0
- Closing Not Located greater than 0
- Resource Designation 01 (primary) or 02 (secondary)
and Resource Owner 03 (DND)

2. The Search and Rescue databases, SARSTAT and SARIS, are maintained in the format of the PC/FOCUS database language. PC/FOCUS is a fourth generation database language which utilizes near-English syntax. This syntax feature allows the general process of a data manipulation program to be easily understood, even by those not familiar with the PC/FOCUS language.

3. The following programs were used to extract SAR case data from the SAR databases for the CASARA base study. The programs are written in the PC/FOCUS language.

Focus Execute Programs to Perform Data ExtractionsSARSTATSDATA STEP 1 GCNEW1B.FEX

USE

```
G:\SARSTATS\SAR83.FOC AS SARSTATS
G:\SARSTATS\SAR84.FOC AS SARSTATS
G:\SARSTATS\SAR85.FOC AS SARSTATS
G:\SARSTATS\SAR86.FOC AS SARSTATS
G:\SARSTATS\SAR87.FOC AS SARSTATS
END
```

-

DEFINE FILE SARSTATS

```
RESTASK/A1=IF (RCOUNT GT 0 AND RES_AGENCY CONTAINS 'DND')
              THEN 'Y' ELSE 'N';
END
```

-

TABLE FILE SARSTATS

```
PRINT CASE_KEY
BY CASE_KEY NOPRINT
IF RESTASK EQ 'Y'
IF INC_CLASS EQ 'A'
ON TABLE SAVE AS GCPRIMA FORMAT FOCUS
END
```

-

DEFINE FILE GCPRIMA

```
RESPRIM/A1=IF CASE_KEY NE ' ' THEN 'Y' ELSE 'N' ;
END
```

-

```

TABLE FILE GCPRIMA
PRINT CASE_KEY RESPRIM
BY CASE_KEY NOPRINT
ON TABLE SAVE AS GCPRIMB FORMAT FOCUS
END

```

```

***** GCPRIMB MUST BE MOVED TO G:\SARSTATS AND THE
***** MASTER FILE EDITED FIELDTYPE = I ADDED
***** PROGRAM GCNEW1C CAN THEN BE RUN

```

DATA STEP 2 PROGRAM GCNEW1C.FEX

```

JOIN CLEAR
JOIN CASE_KEY IN SARSTATS TO CASE_KEY IN GCPRIMB AS JOIN1

```

-

```

DEFINE FILE SARSTATS
DISTRESS/A1=IF INC_CLASSIF NE 'A' THEN 'N'
    ELSE IF CAT EQ '1' OR '2' THEN 'Y'
    ELSE IF PER_FATAL GT 0 THEN 'Y'
    ELSE IF PER_MISSING GT 0 THEN 'Y'
    ELSE 'N';

```

```

SEL/A1 = IF DISTRESS EQ 'Y' THEN 'Y' ELSE
    IF RESPRIM EQ 'Y' THEN 'Y' ELSE 'N';
XDEG/I3 = EDIT(EDIT(LLBSITE,'$$$$999$$'));
XMIN/I3 = EDIT(EDIT(LLBSITE,'$$$$$$99'));
XCOORD/D9.5 = XDEG + XMIN/60.0;

```

```

YDEG/I3 = EDIT(EDIT(LLBSITE,'99$$$$$$'));
YMIN/I3 = EDIT(EDIT(LLBSITE,'$$99$$$$'));
YCOORD/D9.5 = YDEG + YMIN/60.0;
RUN

```

-

```
TABLE FILE SARSTATS
PRINT  CASE_KEY AS CAS_NUM RCC YEAR XCOORD YCOORD LLSITE AS
      LLSITE DISTRESS RESPRIM CAT RCOUNT AS RESCOUNT
      PER_MISSING AS NOT_LOCA PER_FATAL AS FATAL
IF SEL EQ 'Y'
IF LLSITE NE ''
ON TABLE HOLD AS GCNEWSS FORMAT DBASE4
END
```

SARISDATA STEP 1 GCNEW2A.FEX

EX USESARIS

JOIN CAS_NUM IN SARIS TO CAS_NUM IN POSITION AS JOIN1

-

DEFINE FILE SARIS

```
DISTRESS/A1=IF IDE_CLASS NE '01' THEN 'N'
  ELSE IF CLO_LIF_RISK EQ 'Y' THEN 'Y'
  ELSE IF CLO_LOST GT 0 THEN 'Y'
  ELSE IF CLO_NOT_LOCA GT 0 THEN 'Y'
  ELSE IF CLO_HIGH_URG EQ '1' THEN 'Y'
  ELSE 'N';

```

RESPRIM /A1=

```
  IF (RES_DESIG EQ '01' OR '02') AND (RES_OWNER EQ '03')
  THEN 'Y' ELSE 'N';

```

END

-

TABLE FILE SARIS

PRINT CAS_NUM

IF IDE_CLASS EQ '01' OR '06'

IF RESPRIM EQ 'Y'

ON TABLE SAVE AS SARPRIMA FORMAT FOCUS

END

-

DEFINE FILE SARPRIMA

RESPRIM/A1=IF CAS_NUM NE ' ' THEN 'Y' ELSE 'N';

END

-

```

TABLE FILE SARPRIMA
PRINT CAS_NUM  RESPRIM
ON TABLE HOLD AS SARPRIMB FORMAT FOCUS
END

```

```

***** GCPRIMB MUST BE MOVED TO G:\NSPMIS\SARIS\ AND THE
***** MASTER FILE EDITED FIELDTYPE = I ADDED
***** PROGRAM GCNEW2B CAN THEN BE RUN

```

DATA STEP 2 GCNEW2B.FEX

EX USESARIS

```

JOIN CAS_NUM IN SARIS TO CAS_NUM IN SARPRIMB AS JOIN1
JOIN CAS_NUM IN SARIS TO CAS_NUM IN POSITION AS JOIN2

```

```
*****
```

```

DEFINE FILE SARIS
DISTRESS/A1=IF IDE_CLASS NE '01' THEN 'N'
    ELSE IF CLO_LIF_RISK EQ 'Y' THEN 'Y'
    ELSE IF CLO_LOST GT 0 THEN 'Y'
    ELSE IF CLO_NOT_LOCA GT 0 THEN 'Y'
    ELSE IF CLO_HIGH_URG EQ '1' THEN 'Y'
    ELSE 'N';
SEL/A1=IF DISTRESS EQ 'Y' THEN 'Y' ELSE
    IF RESPRIM EQ 'Y' THEN 'Y' ELSE 'N';

```

```

LAT10/A1 = SUBSTR(13,POSITION,5,5,1,LAT10);
LNG10/A1 = SUBSTR(13,POSITION,12,12,1,LNG10);
NEW1_LL/A13 = IF LAT10 EQ ' ' THEN
    OVRLAY(POSITION,13,'0',1,5,NEW1_LL)
    ELSE POSITION;
NEW_LL/A13 = IF LNG10 EQ ' ' THEN
    OVRLAY(NEW1_LL,13,'0',1,12,NEW_LL)
    ELSE NEW1_LL;
XDEG/I3 = EDIT(EDIT(NEW_LL,'$$$$$$999$$$$'));
XMIN/I3 = EDIT(EDIT(NEW_LL,'$$$$$$$$999$'));
XCOORD/D9.5 = XDEG + XMIN/600.0;
YDEG/I3 = EDIT(EDIT(NEW_LL,'99$$$$$$$$$$'));

```

```
YMIN/I3 = EDIT(EDIT(NEW_LL,'$999$$$$$$$$'));  
YCOORD/D9.5 = YDEG + YMIN/600.0;  
END
```

```
-*****
```

```
TABLE FILE SARIS  
PRINT CAS_NUM RCC YEAR XCOORD YCOORD POSITION AS LLSITE  
      SOURCE DISTRESS IDE_CLASS CLO_LIF_RISK CLO_HIGH_URG  
      RESPRIM CLO_NOT_LOCA AS NOT_LOCA CLO_LOST AS FATAL  
IF SEL EQ 'Y'  
ON TABLE HOLD AS GCNEWSAR FORMAT DBASEIV  
END
```

UNCLASSIFIED
SECURITY CLASSIFICATION OF FORM
(Highest Classification of Title, Abstract, Keywords)

DOCUMENT CONTROL DATA		
(Security classification of title, body of abstract and indexing annotation must be entered when the overall document is classified)		
<p>1. ORIGINATOR (the name and address of the organization preparing the document. Organizations for whom the document was prepared e.g. Establishment Sponsoring a contractor's report, or tasking agency, are entered in Section 8).</p> <p>OPERATIONAL RESEARCH & ANALYSIS DIRECTORATE OF AIR OPERATIONAL RESEARCH NATIONAL DEFENCE HEADQUARTERS OTTAWA, CANADA K1A 0K2</p>	<p>2. SECURITY CLASSIFICATION (overall security classification of the document, including special warning terms if applicable)</p> <p>UNCLASSIFIED</p>	
<p>3. TITLE (the complete document title as indicated on the title page. Its classification should be indicated by the appropriate abbreviation (S, C or U) in parentheses after the title)</p> <p>OPTIMAL LOCATIONS FOR NEW CASARA UNITS</p>		
<p>4. AUTHORS (last name, first name, middle initial)</p> <p>CHRISTOPHER, G.L.(DIRECTORATE AIR OPERATIONAL RESEARCH) AND A. McDONALD (NATIONAL SAR SECRETARIAT)</p>		
<p>5. DATE OF PUBLICATION (month Year of Publication of document)</p> <p>APRIL 1996</p>	<p>6a. NO. OF PAGES (total containing information. Include Annexes, Appendices, etc.)</p> <p>77</p>	<p>6b. NO. OF REFS (total cited in document)</p> <p>10</p>
<p>7. DESCRIPTIVE NOTES (the category of document, e.g. technical report, technical note or memorandum. If appropriate, enter the type of report e.g. interim, progress, summary, annual or final. Give the inclusive dates when a specific reporting period is covered.)</p> <p>ORA PROJECT REPORT 9610</p>		
<p>8. SPONSORING ACTIVITY (the name of the department project office or laboratory sponsoring the research and development. Include the address).</p> <p>AIR COMMAND OTTAWA OFFICE</p>		
<p>9a. PROJECT OR GRANT NO. (if appropriate, the applicable research and development project or grant number under which the document was written. Please specify whether project or grant.)</p> <p>PROJECT 23214-9, OPTIMAL CASARA UNIT LOCATIONS</p>	<p>9b. CONTRACT NO. (if appropriate, the applicable number under which the document was written.)</p>	
<p>10a. ORIGINATOR's document number (the official document number by which the document is identified by the originating activity. This number must be unique to this document.)</p> <p>ORA PROJECT REPORT 9610</p>	<p>10b. OTHER DOCUMENT NOS. (Any other numbers which may be assigned this document either by the originator or by the sponsor.)</p>	
<p>11. DOCUMENT AVAILABILITY (any limitations on further dissemination of the document, other than those imposed by security classification.)</p> <p>(X) Unlimited distribution <input type="checkbox"/> Distribution limited to defence departments and defence contractors: further distribution only as approved <input type="checkbox"/> Distribution limited to defence departments and Canadian defence contractors; further distribution only as approved <input type="checkbox"/> Distribution limited to government departments and agencies; further distribution only as approved <input type="checkbox"/> Distribution limited to defence departments; further distribution only as approved <input type="checkbox"/> Other (please specify):</p>		
<p>12. DOCUMENT ANNOUNCEMENT (any limitation to the bibliographic announcement of this document. This will normally correspond to the Document Availability (11). However, where further distribution (beyond the audience specified in 11) is possible, a wider announcement audience may be selected.)</p>		

13. **ABSTRACT** (a brief and factual summary of the document. It may also appear elsewhere in the body of the document itself. It is highly desirable that the abstract of classified documents be unclassified. Each paragraph of the abstract shall begin with an indication of the security classification of the information in the paragraph (unless the document itself is unclassified) represented as (S), (C), or (U). It is not necessary to include here abstracts in both official languages unless the test is bilingual).

In 1976, the Directorate of Air Operational Research (DAOR) undertook a study to identify the optimal regions in Canada where the then newly-forming civil Search and Rescue (SAR) units should be located. In 1995, the Air Command Ottawa Office tasked DAOR to update the study to determine where new CASARA units could be sited to provide the maximum benefit to the SAR system and the Department of National Defence. A methodology, very similar to the one employed in the 1976 study, was utilized to assess the demand for SAR service and the coverage provided by the current CASARA organization. The entire geographic area of Canadian SAR interest was assessed and prioritized with respect to future CASARA unit formation. High demand areas outside of current CASARA coverage were determined to be in northern British Columbia, the Yukon Territory, and the southwestern Northwest Territories. A second region of lesser priority was identified in central Quebec, spanning the area south of Hudson Bay to the mouth of the St. Lawrence River, and extending north into Labrador.

14. **KEYWORDS, DESCRIPTORS or IDENTIFIERS** (technically meaningful terms or short phrases that characterize a document and could be helpful in cataloguing the document. They should be selected so that no security classification is required. Identifiers, such as equipment model designation, trade name, military project code name, geographic location may also be included. If possible keywords should be selected from a published thesaurus, e.g. Thesaurus of Engineering and Scientific Terms (TEST) and that thesaurus-identified. If it is not possible to select indexing terms which are Unclassified, the classification of each should be indicated as with the title.)

SEARCH AND RESCUE
SAR
CIVIL AIR SEARCH AND RESCUE ASSOCIATION
CASARA
BASES
LOCATIONS
OPTIMIZATION
OPTIMAL LOCATION
ALLOCATION

*498430

NO. OF COPIES NOMBRE DE COPIES	COPY NO. COPIE N°	INFORMATION SCIENTIST'S INITIALS INITIALES DE L'AGENT D'INFORMATION SCIENTIFIQUE
1	1	JC
AQUISITION ROUTE FOURNI PAR	► ORA	
DATE	► 16 May 1996	
DSIS ACCESSION NO. NUMÉRO DSIS	►	

DND 1158 (6-87)

 National Defence  Défense nationale

PLEASE RETURN THIS DOCUMENT **PRIÈRE DE RETOURNER CE DOCUMENT**
TO THE FOLLOWING ADDRESS: **À L'ADRESSE SUIVANTE:**

DIRECTOR
 SCIENTIFIC INFORMATION SERVICES
 NATIONAL DEFENCE
 HEADQUARTERS
 OTTAWA, ONT. - CANADA K1A 0K2

DIRECTEUR
 SERVICES D'INFORMATION SCIENTIFIQUES
 QUARTIER GÉNÉRAL
 DE LA DÉFENSE NATIONALE
 OTTAWA, ONT. - CANADA K1A 0K2

Canada